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A NEW 300,000,000-GALLON AQUEDUCT will be started this spring by the Metropolitan Water Board, of Boston. It will be 13.4 miles long, extending from the Sudbury reservoir, in Southborough, toward the metropolitan water district. The aqueduct is to be built of concrete with a brick lining for the lower portion, substantially of the same design as the Wachusett aqueduct, built in 1896-97. For the first 3½ miles the aqueduct will have a grade of 1 in 1,250, and will be 10 ft. wide and 9¼ ft. high; for the remainder of the distance it will have a grade of 1 in 5,000 and will be 13 ft. 2 ins. wide and 12 ft. 2 ins. high. On the line of the smaller aqueduct section there will be three tunnels, having, respectively, lengths of 600, 3,000 and 2,100 ft., a total of 5,700 ft. The first tunnel will be excavated through firm earth and will be lined with brickwork; the others through rock and will be lined with concrete. On the larger aqueduct section, toward its easterly end in the town of Weston, there will be one tunnel through rock, 5,700 ft. in length, which will be lined with concrete. Other features along the line will be a steel pipe crossing the valley of the Sudbury River for a distance of 3,600 ft., and an equalizing and distributing reservoir in Weston, having an area of about 65 acres. Proposals for the construction of the tunnels and portions of the aqueduct, having together an estimated value of from $1,500,000 to $2,000,000, will be asked for as soon as the plans and specifications can be prepared, probably during March. The remainder of the work will not be let until a further appropriation has been made, but it is expected that the letting of all the work will take place during the current year. We are indebted to Mr. F. P. Stearns, M. Am. Soc. C. E., Chief Engineer of the Metropolitan Water Board, Boston, Mass., for the above information.

BIDS FOR THREE PROTECTED CRUISERS were opened at Washington on Feb. 1. They were: Neafie & Levy, of Philadelphia, $2,740,000; Newport News Shipbuilding Co., $2,741,000, and the Bath Shipbuilding Co., $2,750,000. The Newport News company proposes to build a 9,700-ton cruiser on its own plans, for the sum named, in 36 months. The Bath company propose practically the same terms. The Wm. R. Trigg Co., of Richmond, rejected the $50,000 reservation fixed by the Department to cover the cost of placing armor on the cruisers, and propose to build one cruiser for $2,780,000 on somewhat modified plans, or two cruisers for $2,740,000 each. Neafie & Levy company presented its bids on the Department's plans though it omitted automatic witer-tight doors, bronze pilot-house and some other items named. These new ships will be named the "St. Louis," "Milwaukee," and "Charleston," and are to be the most formidable vessels of their class afloat, in ordnance, speed and cruising qualities. Their total displacement will be 9,700 tons each, and they will be equipped with 21,000 I. HP. with twin screw engines, and have a speed of 22 knots. They will be 424 ft. long and 66 ft. extreme beam, and they will carry 1,500 tons of coal. The main side armor is to be 4 ins. thick all around, with upper and lower casemates of the same, and 2½-in. protective decks. On the main deck amidships will be a covered superstructure containing four 6-in. rapid-fire guns and six 14-pdr. rapid-fires. Outside of this superstructure will be two more 6-in. guns, located fore and aft on the center line. On the gun-deck there will be eight 6-in., twelve 14-pdr. and four 1-pdr. rapid-fire guns; and 16 more rapid-fire small caliber guns will be placed on the superstructure and bridges with other batteries in the fighting-tops. The boilers and engines will be protected by the side armor, sloping deck, a 12-ft. coal bunker and a 30-in. cellulose cofferdam. Each ship would be manned by 39 officers and 525 men.

THE TORPEDO-DESTROYER "BAILEY," built by the Gas Engine & Power Co., and Charles L. Seabury Co., of Morris Heights, N. Y., attained a speed of 30.88 knots on an official trial trip at Newport, on Jan. 17. The contract speed was 30 knots.

THE BATTERY FOR THE SEVEN NEW BATTLEships has been decided upon by the Board of Construction, and it is claimed to be the heaviest afloat. It will include four 12-in. and four 8-in. guns in two superimposed turrets, and sixteen 6-in. rapid-fire guns in broadside. Twelve of the 6-in guns will be placed on the main deck on a level with the 12-in. guns; and four more 6-in. guns will be located over the four corner guns in armored casemates. The new 6-in. gun has a length of 50 calibers, and with the smokeless service powder its 100-lb. projectile will have a muzzle velocity of 3,000 ft. per second, and it can be discharged three times a minute. It is claimed that this shot will perforate 5 ins. of the best Krupp armor at two miles range, and more than 6 ins. at one mile. The arrangement adopted saves 300 tons in weight of armament and armor, and this will be added to the coal-bunker capacity, adding 1,800 miles to the cruising radius of these seven 15,000-ton battleships. Five of these ships have already been contracted for,and the other two are provided for in the present Naval bill.

THE NEW AMERICAN NAVY will have cost $310.000,000, when the vessels now authorized are completed, says Mr. Cannon, Chairman of the Appropriation Committee of the House.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred at Dimmick, Ala., on the Alabama Midland Ry. on Jan. 25. Two fast freights collided on a trestle, which gave way beneath them, resulting in a complete wreck of the engines and cars and the loss of four lives. The cause of the collision is said to have been a disregard of orders.

BIDS FOR RAISING THE BATTLESHIP "MAINE," in Havana harbor, were again opened in Wasinhgton on Feb. 1. There were twelve bids, the highest was from Schwartz & Co., of New Orleans, who asked $897,000 for doing the work. The lowest bid was from Chamberlain & Co., who offered to pay the government 3% of the value of the vessel when she is sold.

THE HAVANA FLOATING DRY-DOCK has been rejected by our government, which has no present need for such a dock and declines to purchase at any figure. If it proves to be an obstruction in the harbor, Spain may be requested to remove it.

ROLLING STOCK FOR FRANCE AND SPAIN, to the value of $220,880, was shipped from Philadelphia on Jan. 31. At Marseilles ten locomotives will be landed for the Paris & Lyons Railway; and eight locomotives will be landed at Bilboa, Spain. The same steamer carried 7,428 flat steel billets destined for Newport, England.

THE BROWN SEGMENTAL WIRE-WOUND GUN contracts are said to have been cancelled by the U. S. Ordnance Bureau on Feb. 2. Washington items report that the tests made convince the army officers that these guns are wrong in principle and hazardous in use. The manufacturers demand further tests.

AMERICAN STEEL RAILS FOR VICTORIA is the result of the recent opening of six tenders by the Victorian Railway Department for the supply of 14,200 tons of 80-lb. steel rails, 3,240 tons of 100-lb. steel rails, and 1,880 tons of fish plates. The tenders came from American, English and German firms, and the lowest bids were those of the Illinois Steel Co., of Chicago, and the Lorain Steel Co., of Cleveland, O. The price bid was £5 17s. 9d. per ton, delivered on trucks at Melbourne.

THE CHICAGO TRACK ELEVATION WORK has been fully described and illustrated in our columns, and the annual report of Mr. John O'Neill, Superintendent of Track Elevation, presents a summary of the progress and present condition of the work. Up to Dec. 31, 1900, there had been 318.61 miles of railway tracks elevated and depressed within the corporated limits of the city of Chicago, eliminating 389 grade crossings, at an approximate estimated cost of $17,155,000. Ordinances have been passed by the city council and accepted by the different railway companies for 149.71 miles more of elevation, which when completed will eliminate 156 more grade crossings. The estimated cost of this additional work is $6,558,000, so that when the entire work mentioned above has been fully completed there will have been elevated 468.32 miles of railway tracks, at an estimated cost of $23,613,000. There are two ordinances now pending before the city council: One for the elevation of the tracks on Kinzie St., from Ada St. west to a connection with the elevation of the different railways having their tracks on Kinzie St. The other for the elevation of the Lake Shore & Michigan Southern Ry. and Chicago, Rock Island & Pacific Ry. into the Van Buren St. terminal. There are also prepared and ready to be submitted to the city council in February, the following ordinances: (1) For the elevation of the Chicago, Burlington & Quincy R. R. and other tracks in the neighborhood of Western and Ogden Aves. (2) For the Belt Ry. of Chicago (C. & W. I. R. R.), from Ogden Ave. to Adams St., and from Kinzie St. to North Ave.; the Chicago & Northwestern Ry., from Kinzie St. to Milwaukee Ave. on N. 46th Ave.; the Chicago, Milwaukee & St. Paul Ry., from N. 40th Ave. to N. 56th Ave.; the Union Stock Yards & Transit Co., from Halsted St. east to a connection with the Illinois Central R. R.; the Chicago & Grand Trunk Ry. and the Union Stock Yards & Transit Co., from Halsted St. to South Western Ave.; the Englewood connecting branch railway (operated by the Pittsburg, Cincinnati, Chicago & St. Louis Ry.), from Halsted St. to Leavitt St. (3) For the elevation of the Illinois Central R. R. main tracks from 67th St. to 86th St.; South Chicago branch of the Illinois Central R. R., from the main tracks north of 70th St. to the east side of Stoney Island Ave.; the Baltimore & Ohio R. R., from a connection with the Illinois Central R. R. main line in 70th St. to the east side of Stoney Island Ave.; the New York, Chicago & St. Louis Ry., from Grand Crossing south to 86th St.; the Lake Shore & Michigan Southern Ry., and the Pittsburg, Fort Wayne & Chicago Ry., from South Park Ave. to the east side of Stoney Island Ave.

THE CITY OF GALVESTON, TEX., is to be raised 15 ft. on the Gulf side, if the people can secure the Federal and State aid to be asked for. The proposition also includes the erection of a great breakwater along the whole city front. This is to prevent a repetition of the catastrophe of Sept. 8, 1900, which destroyed 8,000 to 10,000 lives, and nearly 3,000 dwellings, with a direct property loss of $15,000,000. Congress will be asked to authorize a survey on the lines proposed above; the filling to be done by pumping sand from the harbor.

THE TOTAL PRODUCTION OF PIG IRON in the United States during 1900, according to statistics collected by the American Iron and Steel Association, was 13,789,242 gross tons, against 13,620,703 tons in 1899; 11,773,934 tons in 1898, and 9,652,680 tons in 1897. The production in the first half of 1900 was 7,642,569 tons, and in the second half 6,146,673 tons. In 1899 the production for the first half was 6,289,167 tons, and for the second half 7,331,536 tons. The production during 1900, according to fuel was: Bituminous, 11,727,712 tons; anthracite, 1,677,048 tons; charcoal, 339,874 tons; charcoal and coke, 44,608 tons. The production of Bessemer pig iron in 1900 was 7,943,452 tons, against 8,202,778 tons in 1899, a decrease of 259,326 tons. The production of basic pig iron in 1900, all made with coke or mixed anthracite and coke, was 1,072,376 tons against 985,033 tons in 1899, an increase of 87,343 tons. The production of spiegeleisen and ferromanganese in 1900, was 255,977 tons, against 219,768 tons in 1899.

THE LARGEST SINGLE ORDER for alternating current transformers ever recorded has been placed by the Champly Mfg. Co. with the Westinghouse Electric & Mfg. Co. This order comprises twenty 2,750-K-W. transformers of the air blast type. Each of these weighs approximately eleven tons and stands 9 ft. high. Of the 20 units, ten are used to raise the voltage from 2,200 to 25,000 volts at 8,000 alternations. The input is two-phase and the output three-phase. The remaining ten transformers, for lowering the voltage, receive the three-phase line current at 22,000 volts and deliver a two-phase current at 2,400 or 4,800 volts as required. The blowers for furnishing the air-blast for cooling both the raising and lowering transformers are operated by induction motors. In these transformers, both the primary and secondary windings are divided into several flat coils wound with many layers, and few turns per layer, each coil being insulated separately. The advantages of this construction are that it divides the total E. M. F. between the several coils, reducing proportionately the strain in each individual coil; also, it divides the E. M. F. in a single coil between many layers, thus reducing the potential between the adjacent layers. The regulation of the transformers is also improved, and the windings may be connected easily in series or multiple, thus giving a wide range of E. M. F. Also, in case of damage to a coil a substitute may be provided with but little trouble, and without sending the transformer to the works. Iron and copper have been proportioned to secure the minimum losses, and the efficiency of the transformers is very high, being considerably over 98%.

ENGINEERING WORK IN THE CITY OF HAVANA.

(With two-page plate.)

We present on our two-page plate this week a number of engravings from photographs showing the changes wrought in the sanitary engineering conditions of the city of Havana by the work of the U. S. Army engineers under Brig.-Gen. William Ludlow, Military Governor of Havana, and Major William M. Black, Chief Engineer of the Department of Havana. The details of this work are fully given in the report of General Ludlow, which has recently been published in a bulky volume, containing numerous maps, diagrams, and other illustrations, and from these details we abstract the following matter of most general interest to engineers, which is covered particularly by the report of Major Black.

Under the control of Major Black we find the surveys of the city, and its suburbs; the departments of streets, street cleaning and parks, water and sewers, sanitation and renovation of public buildings and fortifications, and the department of the port. In fact, he has created a complete modern department of municipal works; and he reports to Gen. Ludlow that this department is in excellent working order, and is fully up to the requirements of modern cities. While the Island of Cuba can not yet afford a sufficient number of trained Cuban engineers, architects and men fitted to fill even the higher positions in the working force, it has been the policy of the department to give to the natives full opportunity for training in these several positions, and to promote them to higher office as they gain the required experience. In time, they can thus manage their own affairs, without depending too much upon superintendents and foremen obtained from the United States.

FIG. 13.—BOMBA PARK, HAVANA, APRIL 1, 1900.

In street reconstruction—one of the first improvements undertaken—the primary object has been to improve the sanitary condition of the city. The absence of a sewerage system has interfered greatly with the laying down of modern pavement, owing to the enormous cost involved in tearing up and replacing such pavement in the construction of the sewerage system contemplated. A considerable part of the city has been paved with Belgian and Boston block stone pavement, but owing to its noisy character parts of this pavement have been replaced by more modern street covering, especially in the neighborhood of public buildings; and the old stone has been relaid in other streets much in need of block pavement. Within ten months 47% of the macadam streets of the city have been entirely renewed; though, as limestone of widely varying character is the only rock found in the vicinity of Havana that is adapted to this construction, there has been difficulty in securing a proper quality of broken stone in sufficient quantity for this purpose. The price now paid for broken stone, delivered upon the streets of Havana, is $2.30 to $2.35 per cu. meter.

Exclusive of sidewalks and curbing, the macadam streets built have cost from 60 cts. to $1.32 per sq. meter, depending greatly upon the amount of grading necessary. In all nearly 29 miles of macadam streets have been renewed, and 1.5 miles of unpaved streets have been macadamized. Of Belgian and Boston block pavements, 2.6 miles have been relaid in place and over .6 miles have been relaid upon other streets. This stone block pavement is practically confined to the business portion of the city, and the blocks themselves are very irregular in shape, badly rounded by wear and extremely slippery.

Small amounts of sheet-asphalt, asphalt-block and vitrified brick pavements were laid in previous fiscal year for the purpose of obtaining a comparative test of their values in a Cuban climate. The asphalt-block was laid upon a cement mortar bed, and it has quite successfully withstood ten months' traffic; though it is badly worn at a point where the wheels of vehicles follow about the same path in turning a corner. The sheet-asphalt pavement developed a number of small pits, and about 5% of the total have had to be patched by the contractor. The vitrified brick pavement was also laid upon a concrete foundation and a sand-cushion, and it was provided with transverse and longitudinal asphaltic expansion joints. This pavement has given fair satisfaction, though it is very noisy as compared with the asphalt pavements. The average cost of the .62 miles of asphalt-block pavement laid this year was $5.60 per sq. meter. The unit cost of brick pavement is not yet satisfactorily established.

The street traffic in Havana is very extensive and unusually severe upon the roadways. At some points as many as 2,500 vehicles pass in 12 hours; and the ordinary one-mule cart weighs 1,950 lbs. and hauls a load of about 2,000 lbs. on tires 2½ ins. wide. The country cart, which is used in hauling produce or merchandise to and from the city, weighs 4,000 lbs. and carries a load of from 6,000 to 8,000 lbs. on a 3-in. tire. These latter vehicles are drawn by 3 to 6 mules, hitched tandem.

The Department of Street Cleaning and Parks cleans and sprinkles the streets, collects and disposes of refuse and takes care of the parks. It controls an area of 2,101,030 square meters in the streets of the city and its suburbs; and of this area 238,331 square meters are yet unpaved in the city. This work has been thoroughly systematized by dividing the area into nine districts and employing a daily average of 536 persons in this work. Laborers are paid from 84 cts. per day for the first month to $1.00 per day as a maximum; and cart service ranged from $4 to $3 per day. A total of 55,075 tons of street refuse has been already collected and disposed of, and comparative tables show great economy in the new over the old methods of doing this work.

Since December, 1899, certain streets in the city have been sprinkled with electrozone, and this same material was used in disinfecting sewers, gutters and vacant lots, or wherever decomposing vegetable or animal matter were found. There is a house-to-house inspection and cleaning department; and in this sanitary work the worst of the old Spanish military hospital buildings were demolished and the woodwork burned and the stone disinfected. The grounds of these hospitals were also disinfected and regraded with broken stone and cinders. The night-soil and the dinger-out refuse is towed to sea and dumped.

A modern water department has been installed having in charge all that relates to the supply and distribution of water. The Spanish authorities used cast and wrought iron pipe for house connections, as a rule; and it has been found necessary to replace about 1,800 services; using a brass "corporation" cock and service cock, and extra heavy galvanized iron pipe, lead-lined. The dearth of competent mechanics forbade the use of lead pipe in these services. The 400 flush-pattern fire hydrants installed were adopted on account of the narrow streets and sidewalks; but as the valves and their seats were in need of constant repair, 4-in. gate valves are being placed on the laterals connecting with the mains. All new hydrants have a controlling valve, permitting repair.

Since American occupation the water supply has been extended to Casa Blanca and Regla, suburbs of Havana, by carrying for the first a 6-in. flexible joint cast-iron pipe across the main channel in Havana harbor. Regla is supplied by carrying the water 21,000 lin. ft. from a 20-in. main, around to the bay opposite Havana. As much water was wasted by defective fixtures, a house to house inspection was commenced last summer, and out of 11,145 houses inspected 4,073 had leaky fixtures and 3,905 contained closets without storage tanks, the water being permitted to flow constantly in the basins. An ordinance is being prepared to authorize the installation of meters where water is wantonly wasted. All government and municipal buildings have been supplied with modern water fixtures and sanitary plumbing, and an effort is being made to force house owners to do the same, by a system of fines and close inspection.

As a result of surveys made, many of the old Havana street sewers were found to be obstructed by accumulations of deposits. As there were no manholes, the crown of the sewer had to be removed to clean these sewers. No general sewerage system was followed, and the grades were usually laid to meet the requirements of abutting owners; as a result, many localities are deprived of an outlet. Many of the old sewers are rectangular, with sides made of dimension coral rock, with disntegrated mortar in the joints. In some cases the bottom is earth only, and the gradient is flat, as a rule, and the adjoining soil was contaminated.

Thorough surveys were made to obtain data for a modern sewerage system; and upon the completion of the preliminary investigation, Mr. D. E. McComb, M. Am. Soc. C. E., and Superintendent of Sewers, of Washington, D. C., was engaged as a consulting engineer. After devoting four months to the study of the ground Mr. McComb prepared a sewerage plan, as follows: He provided for sewers in all the built-up portions of Havana, with sewer dimensions providing for a population of 500,000. The sewage from all the higher ground was caried by gravity and with interceptor sewer lines to a central point near the harbor entrance; and the sewage from the low areas was to be conducted to a secondary station and then raised by pumps to the high-level interceptor. From the central station mentioned all of the sewage was to be carried under the harbor and to a pumping station on the other side of the harbor, and there lifted sufficiently to flow by gravity to a point of discharge on the coast east of Moro Castle. The plan also provided for storm water sewers where needed; but no sewage was to be permitted to enter Havana Bay. This plan was submitted to Mr. Samuel M. Gray, M. Am. Soc. C. E., but his

final report and detail plans were not completed at the time of making the Ludlow report.

The report states that Mr. M. J. Dady, of New York, in 1895, submitted to the Spanish authorities a project for sewering the city, and sent in a modification of this project in 1897. Mr. D. P. Cunningham, Acting Chief Engineer in the absence of Major Black, reports as follows upon the commercial side of this project: The original Dady project contemplated the collection of all sewage at a central point, the erection of a chemical reduction plant, and a crematory for city refuse, and the discharge of the effluent into the bay. The modified plan of 1897 proposed three separate systems for the collection of sewage, storm-water disposal and subsoil drainage. The first system was to provide for 300,000 people, using 25 gallons of water per day, and this sewage was to be pumped through a pipe to a point 1¼ miles east of Cojimar the collecting basin and pumping station being 7 miles apart. The sewage of near suburbs and that emptied into the bay by Matadero Creek was not provided for.

The specifications are very vague. The minimum width of sewer trench is prescribed, but no maximum is given; and the contractor would be entitled to receive pay for such quantities of material as he might see fit to remove. The great depth of the proposed trenches—13 to 35 ft., involved an enormous quantity of excavation, classified under six heads varying in price from $1.90 to $7.14 per cu. m.; but the project does not specify who is to make this classification. The quality of brick, cement, and vitrified clay pipe are also unspecified. The estimate provides for 24,000 m. of iron force-main, at $25.31 per lin. meter; but the quality, dimensions and weights are unspecified. The trench excavation, estimated for an average depth of 2 m., calls for 48,000 cu. m., at $3 per cu. m. Many other items of excessive cost, superfluous work and freedom from restraint by inspectors are pointed out by Mr. Cunningham.

Mr. Dady's estimate for the sewer system is outlined as follows:

	Spanish Gold.
Estimated cost of sewers	$5,949,848.65
Subsoil drainage	48,144.00
Pumping plant	1,373,490.99
Rain-water sewers	1,036,387.68
Total	$8,407,871.32
Paving	4,192,583.21
Grand total	$12,600,454.53

These amounts include an allowance of 18% for "contingencies, engineering and profit." He proposed in the above to lay 200,000 sq. m. of sheet asphalt pavement, 300,000 sq. m. granite block, and to relay 245,000 sq. m. of old granite block pavement.

Payment for this work was to be provided for by the issue of 6% 50-year Spanish gold bonds, payment on these bonds to be guaranteed by a special mortgage on all the real estate of the City of Havana. The contract is so drawn that the contractor would practically have an unlimited time for completion by extending the five-years named. The contractor was to remain in possession of the work for the lifetime of the bonds, and was to operate the sewer system for that period at the rate of $90,000 per annum. For pavement maintenance the contractor was to receive 10 cts. per sq. m., or $74,581.40 per year, until the maturity of the bonds; this arrangement would insure to the contractor a total receipt for such maintenance of more than $3,300,000, he being the sole judge of the amount of repair necessary, as no representative of the city is designated.

In commenting upon this proposed Dady contract Mr. Cunningham says that there is throughout this contract an entire lack of protection to the city with regard to inspection and acceptance of work, as to sufficiency, quality and satisfactory operation. As a result of the plans made by Mr. D. E. McComb, it is certain that a complete system of sewerage for the City of Havana can be constructed within an expenditure of $5,000,000, and this system would provide for 500,000 instead of 300,000 people, and also include important suburbs omitted in the Dady plan. As to paving, $3,200,000 would give to the city 800,000 sq. m. of modern pavement, which would meet the needs of the present time and cover more than the area specified in the Dady contract. Thus, an expenditure of $8,250,000 would give to the city a more complete and satisfactory system of sewerage and all the modern pavements now needed; whereas, the Dady contract, if carried into effect, would cost $13,000,000 in Spanish gold for the sewerage of only part of the city and an insufficient and badly chosen pavement; and in addition to this lay an annual charge of $165,000 for the maintenance of these systems, exclusive of interest on the bonded debt. Gen. Ludlow's report contains a complete analysis of the Dady specifications by Mr. Samuel M. Gray, which furnishes interesting reading.

Mention has been made of the use of electrozone in disinfecting sewers, etc. The report shows that during August-October, 1899, inclusive, the output of the plant was 16,000 gallons per day of 8 hours; the electrozone showing an average strength of 65 grs. of available chlorine to the gallon. At the present time the output is 24,800 gallons per day with an average strength of 150 grs.; the plant being run 15 hours per day. In ten months 5,157,800 gallons of electrozone were produced, costing $12,656.07, including cost of materials, labor and royalty. The average cost per gallon is thus $0.002453.

THE TOPOGRAPHIC MAPPING OF THE UNITED STATES BY THE U. S. GEOLOGICAL SURVEY.

By H. M. Wilson.*

I.

INTRODUCTION AND EARLY HISTORY.

The civil engineers of the country possess, as a whole, but an indefinite knowledge of the vast amount of useful engineering data, which are being accumulated by the surveys of the Federal Government. Three branches of the Government service have been engaged for many years in engineering surveys of national extent; namely, the Coast and Geodetic Survey, the Lake and River Surveys of the Engineer Corps of the Army, and the Topographic Branch of the Geological Survey.

The Coast Survey has practically charted the entire coast line of the United States, including all navigable harbors and tidal streams. A large proportion of this work is accompanied by topographic mapping of a narrow strip, from one to three miles in width back of the shore line. The topographic mapping of the Mississippi and Missouri River Commissions and of the Lake Survey closely resembles in character and scope the work of the Coast Survey, the results extending back from the shore lines for a relatively short distance. The most important organization of the Federal Government in extent and results of inland topographic mapping, is the Geological Survey. During the 22 years of its existence this bureau has mapped 872,000 square miles, or nearly 30% of the area of the United States, exclusive of Alaska, distributed as shown by the map, Fig. 1, and by the diagram, Fig. 2.

It is the purpose of this and two similar articles which are to follow, to place before the engineers of the country in as compact form as possible a statement of the progress made in the extension of: (1) the topographic mapping; (2) the primary triangulation and precise leveling; and (3) the hydraulic and forest surveys of the various bureaus of the United States Government. It is hoped that this statement of progress will point out to the members of the engineering profession places in which they may look for existing material which may be of assistance to them in their work.

Between 1867 and 1882, the Wheeler, King, Powell and Hayden surveys mapped on geographic scales 613,000 square miles west of the Mississippi River. While all has been of much value in advancing the general development of the far west, none is of sufficiently high quality or of large enough scale to be of value in planning engineering works. Hence, as the area of the inland mapping of the Coast Survey and the Lake and River Commissions have been shown to be inconsiderable in extent, and the results are assimilated into the topographic maps of the United States Geological Survey, it becomes only necessary to consider the map surveys of the latter organization to show the extent of existing general map material which is of engineering value.

*U. S. Geological Survey, Washington, D. C.

Of the 872,000 square miles of topographic mapping by the Geological Survey, about 360,000 square miles was the product of early preliminary surveying on the geographic scale of four miles to 1 inch, and with contour intervals of 200 to 250 ft. This cannot, therefore, be considered as of engineering value. Its extent is indicated upon the accompanying progress map. Of the remainder, all of the New England and Middle Atlantic States, and portions of the Central States, being roughly that area north of latitude 39° and east of the Mississippi River, and small portions of Louisiana, Florida and California, have been mapped on the natural topographic scale of one mile to 1 inch, elevations and surface relief being expressed by contour lines located with relative accuracy at intervals of 5 to 20 ft., vertically. The remainder, that portion of the United States which is least densely inhabited or least highly eroded, is mapped on a scale of two miles to the inch, and with contours having vertical intervals of 20 to 100 ft. Nearly all of the latter work, and certainly all that has been executed within the last ten years, is of sufficient accuracy to permit of its being shown on the scale of the resulting map in such detail as to give it high value in connection with the planning of engineering works.

UTILITY OF THE SURVEYS IN ENGINEERING WORKS.

Though the value of these maps for such purposes is well understood, it may not be amiss, in order to give a more definite appreciation of their uses, to recite some of the utilities to which they have been put in recent years. They are extensively employed in the planning of new lines of railway, and in the improvement of the alinement of existing roads. After laying down the line of the Washington & Chesapeake Ry. on these maps, and running out the location in accordance therewith, the chief engineer found that he had to rerun very little, and that the improvement in the line previously located without the aid of the maps amounted to the reduction in number of curves, from 107 to 6, being a total saving of 3,266° of curvature, and resulting in the shortening of a line less than 50 miles in length by 4.7 miles. In municipal engineering the case of the city of Waterbury, Conn., may be cited. After expending $10,000 in examining sources of water supply the city engineer obtained from an inspection of the government topographic maps a far better supply from a source, the availability of which had been previously unsuspected. The recent extensive investigations of the water supply of New York city for the Comptroller and for the Merchants' Association, would have scarcely produced such definite results had it not been for the existing topographic maps. Their value proved so great during that investigation as to cause at least one of the reports to recommend that the city appropriate a portion of the money required to complete the topographic map of the possible areas of future water supply.

The State Board of Health of Massachusetts finds the general topographic map of the greatest assistance in expediting a comprehensive preliminary study of sources of water supply and of water pollution. The chief engineer of that Board has found that he can now make in a day as much progress in that work as he could in two or three months prior to the existence of the topographic map. The Highway Division of the State Engineer's office of New York finds these maps of inestimable service in planning improvements of existing roads. The lines of through highways which are to be improved are selected on the topographic map, the contours rendering it possible to ascertain the routes having best alinement and grades, and the maps are especially valuable in connection with the letting of contracts for the delivery of material at points most accessible to railways. The work of the various State and Federal Commissions engaged in studying routes for enlarged barge or ship canals through the State of New York, has been greatly facilitated by the existence of general topographic maps showing the detailed configuration of the country in which possible lines of canal may be sought.

PLAN AND SCOPE OF THE SURVEYS.

The topographic survey of the United States is being prosecuted under annual appropriations by

Congress of nearly $350,000 for the triangulation and topographic divisions of the Geological Survey. A further sum of about $50,000 is devoted to allied work through the Coast and Geodetic Survey. In addition, various States have, in order to expedite the completion of the map of their areas, appropriated large sums to be expended in co-operation with the United States Geological Survey, and under its direction. The interest of State officials in the speedy prosecution of this work is evidenced by the fact that the States of Massachusetts, Connecticut, Rhode Island and New Jersey have each appropriated half the sums required to complete the mapping of their areas in co-operation with the United States Geological Survey. The States of Pennsylvania, New York, Ohio, Maine, Alabama and Maryland are annually appropriating nearly $75,000 to expedite the mapping of their areas. In addition, state geologists, state engineers and other officials in North Carolina, Georgia, Illinois, Missouri, Mississippi, Kansas, the Dakotas, Nebraska and California urge annually through their representatives in Congress or directly, the survey of special areas, the maps of which are essential to local problems in which the states are interested.

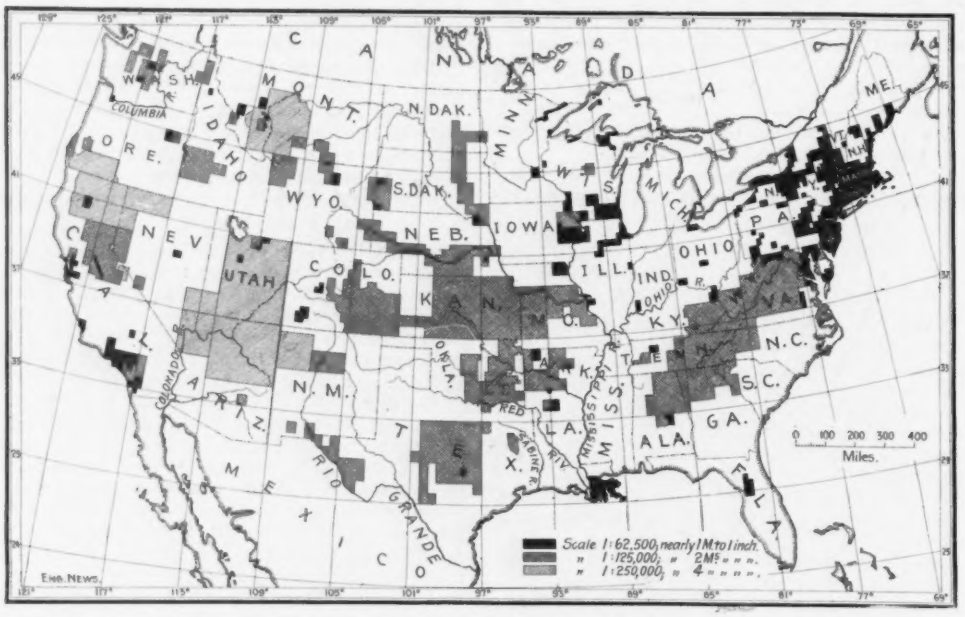

FIG. 1.—MAP OF THE UNITED STATES, SHOWING AREAS SURVEYED AND MAPPED BY THE TOPOGRAPHICAL BUREAU OF THE U. S. GEOLOGICAL SURVEY.

The results of the topographic survey of the 3,025,000 square miles of the United States will require several thousand map sheets for its representation. If the present proportion be maintained of 1,000 atlas sheets to represent the topography of ¼ of the area of the country, 4,000 such sheets will be required for the great topographic map of the country, exclusive of Alaska and the Ocean Islands. The field of work is extremely diversified, comprising as it does broad plains, high and rugged mountains, canyoned plateaus and low rolling hills. Moreover, some portions of the country are densely settled, while others are devoid of inhabitants; some are open while others are covered with dense growth of forest. As a result it is impossible to select a common scale or scheme for mapping the entire country. Accordingly, the least number of scales have been adopted, and it is believed that aside from special areas of great economic importance, the whole of the country may be mapped on the scales of either one or of two miles to the inch, but with varying contour intervals according to the degree of relief.

In order that so great a number of atlas sheets may constitute a homogeneous map, it has been impossible to regard state or other natural or artificial boundary lines. The whole of the country has been divided into quadrilaterals of 15′ or 30′ of latitude and longitude, according to the scale, and the survey of each is completed regardless of all surface features. Such a plan involves no additional expense, and possesses some advantages in planning and prosecuting both field and office work, and renders it possible to arrange the atlas sheets in groups representing counties, states or other subdivisions of the surface.

METHODS AND COST OF WORK.

Starting with two or more primary triangulation stations within the area of the quadrilateral to be surveyed, a secondary scheme of triangulation is extended by planetable by which tertiary points are located with such frequency as to give an average of from one to three good locations per square mile, equivalent to the same number per square inch of map. Elevations are determined of all triangulation points, which are chiefly hill summits, by vertical angulation depending on spirit leveling. Also of all the lower relief of the country by lines of spirit levels run from 3 to 6 miles apart. Where the lack of surface relief, or the density of forests is unfavorable to the execution of triangulation, the primary and secondary control consists of a system of primary traverses checked by astronomic positions or primary triangulation locations.

A second system of horizontal control consists of odometer traverses of all roads and trails, or where these are not sufficient, of stadia or taped traverses across country and about the shores of lakes and streams. These traverse lines are run by compass and plane-table, and are plotted upon the board as the work progresses, and are adjusted upon the map between the frequent locations resulting from the primary traverse or the plane-table triangulation. The distances between check points on such traverse are so relatively short, being from one to four miles, that the error of location is scarcely perceptible upon the scales of one or two miles to the inch and an adjustment to the better positions becomes easily possible.

The primary triangulation and precise leveling is executed a season in advance of the topographic mapping. The determination of secondary positions by plane-table triangulation, road and stadia traverse and flying levels, proceeds together a little in advance of the sketching of the map, but by members of the same party. The results of the adjustment and transfer of all traverse lines and level elevations to the secondary locations is a control or sketch sheet upon which are from two to five trigonometric locations per square inch, from 4 to 8 ins. of road traverse per square inch and an average of one to two instrumental elevations per square inch. On this base the topographer then proceeds to sketch the topographic forms.

Placing himself at a known position, the height of which is already determined, the topographer sketches with the aid of hand-level and by eye the plan of the contour line passing through his position on the map, and it may be possible to locate this for a distance of half a mile, the equivalent of half an inch, in either direction. If the country be wooded it cannot be seen beyond his absolute position. Proceeding now over the road, preferably by vehicle, he stops at greater or lesser intervals, according to the amount of change of slope, carrying differences of elevation for short distances between check points by aneroid. When good elevations are insufficient more are procured by flying levels or by vertical angulation, as the work progresses. In this way a network of topographic contouring is built up everywhere along the lines of roads, and these are frequently so near together that the contours meet and fill up the entire surface of the map. Otherwise the topographer walks in between roads, pacing distances if short, or running stadia line, if necessary, and thus he fills in the interior of the road circuits and completes the map. By this method of selecting the easiest routes of travel, and those over which speed may be made by use of conveyances, much greater progress can be made with as great accuracy as by any method of cross-sectioning at fixed distances or running out highest and lowest lines of relief.

This general method is necessarily much modified, according to the conditions. In country which has been subdivided by the Public Land system, the section lines are used as a system of secondary control, and over these the first sketching is done. In dense woods, as in the Adirondacks, Wisconsin, etc., traverse lines with stadia, chain or tape, are run on the checkerboard system of distances, of ½-mile or less apart, thus completely cross-sectioning the area under survey. The cost of general topographic mapping varies greatly with the scale and with the conditions of relief and woodland. For the one-mile scale, in fairly open country, it is from $6 to $10 per square mile. For country which is highly eroded and densely wooded it ranges up to from $15 to as high as $30 per square mile. For the two-mile scale the cost is about one-third less.

The charts of the coast of the United States can be purchased of the Superintendent of the Coast and Geodetic Survey in Washington for trifling amounts. Those of the great rivers and lakes from the Chief of Engineers of the Army.

The results of the topograhic surveys of the Geological Survey are being published on so-called atlas sheets of uniform size. This name has been selected because each is to be but the first sheet in an atlas of the area represented, and is to be accompanied by other sheets showing the classification of the lands, as forest, cultivable, irrigable, etc., also the surface geology and the distribution of the economic stones and minerals. To date, about 1,000 topographic sheets have been published, and are procurable for nominal prices on application to the Director of the United States Geological Survey. Each atlas sheet is approximately 16½ ins. wide by 20 ins. long, and represents the topography of a quadrilateral of the earth's surface of 15′ to 30′ in extent, according as its scale is one or two miles to the inch. The maps are engraved on copper plates, three for each sheet, one showing in blue the hydrography, or water features, as ponds, streams, lakes, etc.; another in brown, the hypsography or relief of surface forms, as hills, valleys, etc.; the third in black, the culture, or features constructed by man, as cities, roads, political divisions and the names printed upon the map. The result of this combination of colors is to exhibit clearly and legibly the various topographic facts.

THE CHEMISTRY AND PHYSICS OF CAST IRON.

In the "Journal of the Franklin Institute" for May, 1900, there was published an article by Mr. Paul Kreuzpointner entitled "Riddles Wrought in Iron and Steel." A large part of the quite long discussion of this article was confined to matters concerning the chemistry and physics of cast iron. While many of the questions brought up were of interest principally to the chemist and physicist, there were some others of more direct interest to the engineer, and these we have collected in the following paragraphs abstracted from

the issues of the Journal for May and November, 1900.

Mr. William R. Webster—I would like to ask the following questions: (1) Can white iron castings be changed to good gray iron by annealing? If so, what is the gain in strength over corresponding gray iron castings produced in the ordinary way? (2) I would also like to know what changes can be produced in good gray iron castings by heat treatment alone. In these questions I do not refer to any changes depending upon the total amount of carbon or other element present, for instance, by treatment with oxide of iron or other material, but merely to simple annealing (as generally understood for steel), in the first case, and heating and quenching in the second.

Mr. A. E. Outerbridge, Jr.—If a bar of steel is heated to a certain temperature and suddenly quenched in cold water, it will become hard and more or less brittle. In like manner, if a bar of ordinary gray cast iron be heated to a certain degree (which may be called the "critical temperature") and suddenly cooled by immersion in a chemical solution of various salts, or even in cold water, it will become extremely hard, not merely upon the surface, but throughout the mass. I should, perhaps, explain that I do not now refer to so-called "chilled iron,"

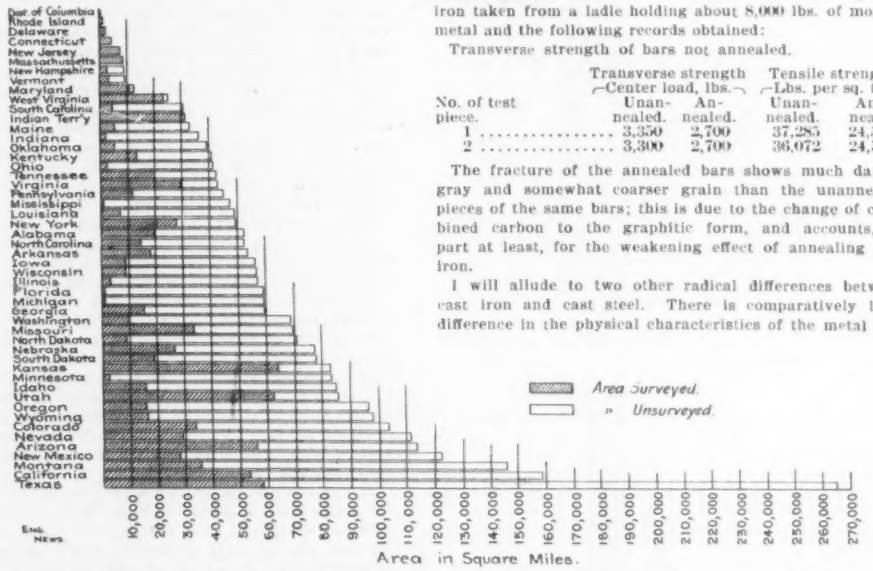

FIG. 2.—DIAGRAM SHOWING THE SURVEYED AND UNSURVEYED AREA OF EACH STATE AND TERRITORY; U. S. GEOLOGICAL SURVEY.

i. e., a metal in which the carbon and iron are in chemical union, having a characteristic crystalline structure and white color.

It is possible, in this simple manner, to change a comparatively soft gray iron casting into a metal as hard as steel; in fact, cutting tools for lathes and planers have been made of common gray cast iron thus hardened, not "chilled" on the cutting edge. The hardened bar of cast iron is very brittle and the fracture is much lighter in color than the original metal, closely resembling tool steel. Singularly enough, this fact does not seem to be universally known, yet this is one of the few instances in which cast iron and steel behave alike under similar conditions. But you may say, "What about the strengthening of cast iron by annealing; is there not a close analogy in this respect to steel?" I answer emphatically "No!"

It is, of course, very well known that some castings, such as chilled cast-iron car wheels, are greatly improved in strength by annealing in heated pits for a period of from three to five days, and from this fact it is generally assumed that annealing cast iron strengthens the metal. Nevertheless, I am prepared to make the positive statement—which may seem startling in view of the widespread belief to the contrary—that annealing gray cast iron by heat invariably weakens the material. How, then, can we explain the apparent anomaly that a cast-iron car wheel is strengthened by heat annealing, if it be true that gray cast iron is invariably weakened by heat annealing? This is a riddle that may be readily solved.

A chilled cast-iron car wheel is subject to abnormal cooling strains due to the conditions under which it is cast. If a car wheel is allowed to cool in the air, like an ordinary casting, the cooling strains are sufficient to overcome the molecular cohesion of the metal and usually to cause the wheel to break asunder with a loud report; but if it is placed, while still red-hot, in an annealing pit and allowed to cool very slowly, these strains are gradually eliminated and the casting then becomes exceedingly strong. If now you ask, "Is the gray metal of which the plate of the wheel is made as strong after annealing as before?" I say, positively, it is not. Such a statement, however, to be convincing and to have practical value, must be accompanied by irrefragable proofs. Several years ago I made many experiments to ascertain the facts in the case, and very recently I have repeated some of these tests with entirely corroborative results.

Several bars of cast iron of various grades, ranging from soft pulley metal, having a tensile strength of about 18,000 or 20,000 lbs. per sq. in., up to very strong iron showing over 40,000 lbs. tensile strength to the square inch (on bars of 1-in. section cast 30 ins. long), have been made and tested, both before and after annealing, within the past few weeks.* The modus operandi was as follows: The bars were first broken once upon a testing machine with supports 12 ins. apart and the transverse strength of the unannealed metal was thus ascertained; one of the pieces of each bar was then turned in a lathe and pulled on a testing machine, thus the tensile strength of the unannealed bar was also determined. The remaining pieces of the bars were then placed in the annealing furnace and subjected to high heat for nine hours; the bars were then very slowly cooled while still enclosed in the annealing cases to protect them from the oxidizing effect of the air. The annealed pieces were then treated in precisely the same manner as were the unannealed pieces of the same bars to ascertain the transverse and tensile strength. In every case the annealed bars were much weaker than the unannealed portions of the same bars. Two recent tests will suffice to illustrate this. Two bars 30 ins. × 1 in. × 1 in. were poured from strong cast iron taken from a ladle holding about 8,000 lbs. of molten metal and the following records obtained:

Transverse strength of bars not annealed.

No. of test piece.	Transverse strength —Center load, lbs.— Unannealed.	Annealed.	Tensile strength —Lbs. per sq. in.— Unannealed.	Annealed.
1	3,350	2,700	37,285	24,500
2	3,300	2,700	36,072	24,500

The fracture of the annealed bars shows much darker gray and somewhat coarser grain than the unannealed pieces of the same bars; this is due to the change of combined carbon to the graphitic form, and accounts, in part at least, for the weakening effect of annealing cast iron.

I will allude to two other radical differences between cast iron and cast steel. There is comparatively little difference in the physical characteristics of the metal in a large or in a small casting poured from one ladle of molten steel, but there is a great difference in the character of gray cast iron when poured from one ladle into large and small castings. Furthermore, there is a lack of homogeneity in different parts of the same casting, causing wide variations in the physical properties of the iron. This was proved in a conclusive manner in some tests made twelve years ago.

In the foregoing remarks I have referred to the effect of heat treatment on gray iron exclusively, but Mr. Webster asks, "Can white iron castings be changed to good gray iron by annealing? If so, what is the gain in strength over corresponding gray iron castings produced in the ordinary way?"

In answer to this I would say that about twenty years ago the curious discovery was made that white iron, forming the hard wearing surface, or "tread," of some chilled cast-iron car wheels which had been accidentally overheated in an annealing pit, had been completely changed to soft, fine-grained, dark gray iron, by the heat treatment. No practical use was made of this discovery at that time, but recently, the principle has been applied commercially, with success, to the production of very strong gray iron castings. These castings are made originally of white iron, subsequently changed to the gray condition by annealing, and tests made by Richlé Bros. of this converted gray cast iron show remarkably high tensile strength, ranging from 50,000 to 67,150 lbs. per. sq. in. Axes, hatchets and other cutting tools are now made of white cast iron, then annealed to change them to gray iron (without decarbonizing, as in the malleableizing process) and subsequently hardened, on the cutting edge, by heating and sudden cooling. Such tools are now sold under the name of "steel castings," but this is, I think, clearly a misnomer. The metal is not steel, neither is it malleable iron, and it may be defined as a new commercial product standing between cast iron and steel, partaking somewhat of the qualities of each. In this process the heat treatment, or annealing, has changed a hard, brittle, white cast iron, only fit for sash weights, into an exceedingly strong, fine-grained machinable metal, suitable for many valuable purposes and for which I think there is a wide field of usefulness in the future.

In reply to still another question of Mr. Webster, I would say that the grain, or texture, of gray iron in small castings may be very materially altered by slow cooling. For example, I have found by actual tests that light castings of thin section, made in a mold with a large casting, in close proximity thereto, will have more open grain and will be much softer than similar light castings poured in a separate mold from the same iron. There are other ways in which the same effect can be produced by prolonging the cooling of the metal in small castings, and in this way the necessity for annealing such light castings to make them more readily machinable may perhaps be obviated.

Prof. Henry M. Howe—After considering Mr. Outerbridge's discussion, I should like his answers to the following inquiry: What composition do you think gives the strongest cast iron? What the highest combination of strength with ductility?

Mr. Outerbridge—I beg to answer Professor Howe's question as follows: The first query is too general to admit of a definite answer. The "strongest iron" for a casting of, let us say, 1,000 lbs. weight and 4-in. section in its thickest part, would not be the strongest iron for a casting of say 50,000 lbs. weight and correspondingly heavy section. Conversely, the strongest iron for the larger casting would not be the strongest iron for the smaller one. Cold-blast charcoal iron combines in the highest degree, strength and ductility.

Mr. Wm. R. Webster—I do not agree with Mr. Outerbridge's conclusions from the tests he refers to on annealed test bars of cast iron. These bars give more deflection after being annealed than before, and, as he has already stated, their breaking strength was less. I think he will also agree that this material, in its annealed condition, will withstand shock better than before annealing. He has made out a very good case, showing the similarity between annealed cast iron and annealed steel, for in steel, when it is properly annealed, we have a reduction in strength, an increase in elongation, and also an increase in reduction of area. The material is much better fitted to withstand shock.

The other point, as showing the difference between cast iron and steel, in that the size of the grain of the cast iron depends on the mass of metal in the castings of iron, and that this difference in the size of the grain does not take place in steel, I do not agree with either.

The difference does exist in steel, but not to such an extent as in the cast iron, and, as a general thing, in steel the castings are annealed, and this breaks up the large grain and produces the fine structure so much desired. Sir Henry Bessemer, some years ago, by slowly cooling a mass of molten steel, produced a very large grain in the metal, and, I think, taking everything into consideration, Mr. Outerbridge will have to modify his conclusions in both of the above cases.

I would now like to ask Mr. Outerbridge if in his experience, knowing the chemical composition of a series of 1-in. square test bars, made under the usual conditions of practice for one grade of metal, he can, from the chemistry, tell what the breaking load would be for these bars.

(2) If, having the breaking load of these bars, the chemical composition and the deflection of the bars, he can estimate closely what the results of such metal would be in large castings, small castings and medium-size castings.

(3) In making up the mixtures for the cupola, do you depend at all upon the fracture of the pig iron used, or do you treat the whole matter as just so much iron, carbon, phosphorus, sulphur, etc., irrespective of what the fracture of the metal may show?

(4) How closely can you estimate, from the composition of the mixture charged in the cupola, what the composition will be of the metal tapped from the cupola; in other words, what changes will take place in the melting of the iron?

(5) Can you so arrange your cupola mixtures as to produce a casting of a given chemical composition that you aim at to start with?

(6) If you can carry on your work, as indicated above, I would like to ask if you can estimate the strength of your test bars from the chemical composition of your charge, making allowances, of course, for the changes that occur in melting the metal.

(7) As a final question in this line, I would like to ask what elements you use in estimating the strength of your test bars, and the general method of doing this work; that is, the amounts per unit for the elements that you consider, and how these figures are modified, owing to the relation of one element to the others.

Mr. Outerbridge—For the sake of brevity I think it will be advisable to group several of Mr. Webster's questions together in my replies thereto. With regard to his deduction from the records of annealed and unannealed test bars of cast iron, given in my first communication, that, notwithstanding the decrease in strength of the annealed bars, they were better able to withstand shocks, as indicated by an increase in deflection, I would say that a calculation of the "resilience" of the bars, made by Prof. J. B. Johnson's rule, shows a large decrease in resilience of the annealed bars, due to the fact that the increase in deflection was far less, relatively, than was the

*This discussion took place on March 14, 1900.

decrease in strength. With regard to Mr. Webster's next point, I would simply call attention to the wording of my original discussion, in which it appears that, in referring to the great difference in grain, or fracture, of cast iron in large and small castings, I said, "no such great difference exists in steel castings," but did not say that there is no difference in grain in large and small castings made from one ladle of molten steel.

Replying to questions 1 and 2, I may say that for many years past it has been my aim to produce castings, day after day, varying from the smallest sized pulleys with rims about ¼-in. thick up to immense machinery castings weighing 40 or 50 tons, and requiring very different mixtures of iron, in which the test bars shall not vary in strength more than 5% from the predetermined standards of strength (transverse and tensile) for castings of any given kind. I am sure, from a review of records extending over a good many years, that the average variation is less than 10%, and such variations would probably be still less if it were practicable to melt only one grade of metal in a cupola in one heat. Commonly, three different grades of iron are melted in one heat, viz., soft iron for pulleys and light work, moderately strong iron for "medium" work, and very strong iron for special castings, generally of large size. The transverse strength of 1-in. square test bars 15 ins. long, broken with supports 12 ins. apart, varies from about 2,000 lbs. for soft iron to 4,000 lbs. (center load) for strong iron, and the tensile strength ranges from about 20,000 lbs. to about 40,000 lbs. per sq. in.

(3) The fracture of the pig iron is carefully noted when the iron is received in the yard, not so much as a guide to subsequent mixtures in the cupola, but because it is an indication of the working condition of the furnaces from which the iron was purchased. It may be stated, however, that more attention is paid to the fracture of the pig iron in making charges for pulleys and small work than in making mixtures for large castings.

(4-5) The resultant castings ordinarily agree very closely with the composition of the mixture charged in the cupola, as a certain allowance is always made for burning out of the metalloids in melting. For example, a casting, such as a car wheel, which should contain by calculation from the mixture 0.7% of silicon, will rarely, if ever, be found to vary more than 1-10 of 1% either way from the standard. In like manner, a casting made from a mixture of different kinds of pig iron having very different proportions of silicon, but averaging 2¼% of that element, will rarely be found to vary more than ¼ of 1% from the standard.

(6) The strength of test bars depends largely upon the size of the bars. Two bars cast in the same mold from the same ladle of iron, from a good mixture, one bar being 1¼ ins. diameter and the other 1¾ ins., both turned to the same size, say 1.129 in. (= 1 inch area), will show a variation of about 20% in the tensile strength of the two bars, the larger bar being the weaker, assuming, of course, that both bars are gray iron. I have already stated that the strength of the test bars can be approximately estimated from a knowledge of the composition of the mixtures.

(7) I regard the element silicon as the most important of all in determining the question of strength of foundry iron, not because this element imparts strength or weakness to iron per se, but because it controls the condition of the carbon, whether graphitic or combined.

Other elements, such as phosphorus, sulphur, manganese, etc., all exert their influence, but it is not very difficult to guard against the danger of introduction of any of these elements in injurious proportions, while some of them, when present in moderate amount, are beneficial.

In reply to Mr. Webster's final questions, I would say that the kinds of foundry tests which shall show the physical character of the metal before pouring depend so largely upon the character of the castings to be made and kind of metal melted that the methods adopted in one establishment may not be at all suitable to another. So far as I know, there are few general foundries where rapid tests are made during the run of iron, and the consequences of such neglect are sometimes serious, for castings are poured from metal unsuitable for the work, this fact not having been known at the right moment to prevent the error.

Finally, I may say that I am convinced that the presence of iron oxide dissolved in the molten metal is a factor which is commonly overlooked, and is to be feared, especially in strong iron mixtures. The best deoxidizer with which I am familiar is ferro-manganese, a metal containing about 80% manganese, which may be added either in the ladle or in the cupola in the proportion of about 1 lb. to 600 lbs. of iron. The effect is to increase the strength and ductility, to decrease the chill, and to darken the gray color of the fracture in high-chilling iron mixtures. This discovery was first brought to the attention of metallurgists in an address given at the Franklin Institute in February, 1888, on "Pig Iron, Including the Relation Between Its Physical Properties and Its Chemical Constituents."

Since that time the beneficial effects of ferro-manganese as a deoxidizer and desulphurizer in certain iron mixtures have become quite generally known, and its extensive use, especially in car wheel foundries, has followed thereupon.

HYDROSTATIC TOOLS IN RAILWAY SERVICE.*

By George L. Gillon.

The best system of portable lifts for heavy weights has occupied a large amount of attention and study during the past decade, and the result seems to indicate a conclusion that the hydraulic system is the most reliable and economical. It apparently remains the popular decision that in heavy lifting (say ten tons and over) the advantages to the credit of the hydraulic tool more than offset the advantages in the geared or screw tool.

HYDRAULIC SHOP JACKS.—As a safety device for lifting heavy weights these are the best tools to-day. No screw or geared jack can take their place in economy and safety. In Fig. 1 the ram (A) is made in one piece. This is done by taking high-carbon machine steel bars, and drawing them down from the largest diameter; the interior is then drilled out for the reservoir, using a large twist drill in a special drilling machine constructed for this purpose, and a small twist drill for the pump chamber (B). This method produces a solid ram, in which the flange screwing into the head and the pump chamber walls are in one solied piece without any welds or forced joints.

The common construction in the jacks on the market today is of seamless tube, as in Fig 2, in which the flange for the head is brazed on at (M), and a sleeve for the pump chamber forced in the bottom of the tube, making

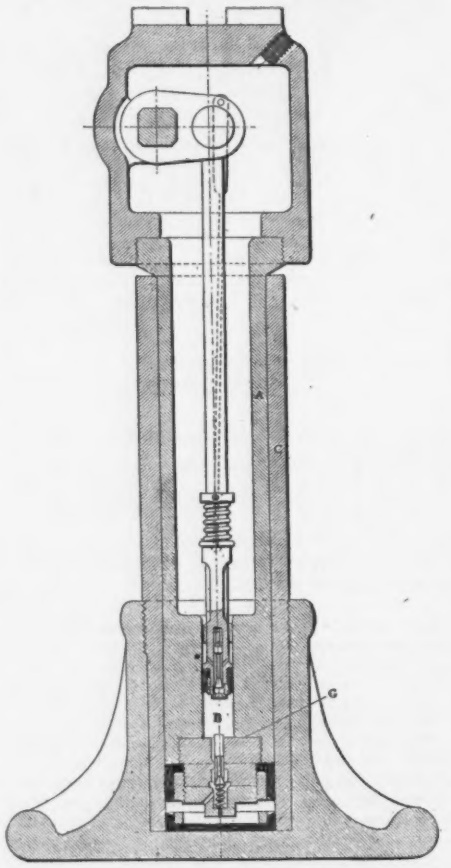

Fig. 1.—Hydraulic Jack.

three distinct pieces to the ram in the place of one piece in the former ram. There can be no argument advanced in support of these additional or unnecessary parts in a jack ram. The principle in all high pressure hydrostatic work is to avoid, where possible, all joints, turns or bends in pressure conduits, and employ the least number of parts possible. Making the flange which fastens by a screw thread in the head solid without welds may cost a trifle more to produce, but it certainly presents a better ram, and there can be no question whatever as to its strength at that point.

The practice of using the loose pump (L), as shown in Fig. 2, should also be abandoned. There is no wear upon this part sufficient to warrant its retention. The constant liability of its becoming loose is too great an element of risk to justify the small saving of cost in manufacture. The cylinder (C) in the jack, in Fig. 1, is made in a similar manner to the ram. A bar of high carbon machine steel is cut to proper length and a straight hole nearly full size drilled through the solid stock, removing the center of the bar, which has less density. This interior surface is then ground to a fine finish and exact size to suit the ram. The material used being very clean and free from seams after being highly finished inside, will be found to wear very even and smooth and prolong the life of the packings to a great degree.

*Abstract of a paper presented at the January meeting of the Western Railway Club, Chicago.

In the jack cylinders in common use, manufact[illegible] use seamless drawn tube or castings, which, in the [illegible]ter's judgment, is poor material for the purpose. [illegible]mless tubing cannot always be surfaced sufficiently sm[illegible]h to make a good jack cylinder, nor is a seamless tub[illegible]m in three parts as efficient as a steel ram in one piec[illegible] described heretofore. In finishing seamless tube c[illegible]ders it is often necessary to remove more stock than [illegible]al in order to reach below some surface defect, and in [illegible] endeavor to avoid these defects it frequently happ[illegible] that another flaw is developed. It thus results that [illegible]ely two cylinders can be finished alike, and even w[illegible] this variation it is doubtful that any are properly or p[illegible]ctly finished. These surface defects being of a seamy [illegible]ure, even though they be but slight, retain the liquid a[illegible] rapidly rust the cylinder; the moment rust forms the [illegible] begins to cut, repacking becomes frequently necessa[illegible] and the jack is more often and for longer periods out of order than it is in proper repair.

In this analysis of the pack interior there is anothe[illegible] very important matter which it is well to emphasize; that is, the release. There is as much trouble caused by defective releasing as there is by faulty construction. In releasing any design of jack that has come under the eye of the writer, no particular skill is required, nor is it necessary to confine the operation of the jack to only the higher grades of workmen. It is not always possible to provide machinists or mechanics to handle jacks, and any jack which would require special instructions to operate would harly meet with popularity. Manufacturers generally seem to have anticipated this point, and all jacks, so far as the release is concerned, are very simple to operate. There is, however, one principle which should always be observed in lowering a heavy weight with a jack; that is, care. In all cases where a jack is pumped up under a high pressure, it should be released with extreme care and caution and without any excessive or a quick force applied to the lever.

If the lever is forced down rapidly it will force the valves wide open too suddenly, which causes a swift rush of the liquid through the valves and ports, and may at times be of sufficient velocity to reseat the valves, thus throttling the return passages and stopping short the descent of the ram. To properly release the jack, the lever should be raised easily ⅛-in. to 1 in. which causes the piston valve to drop away from its seat; then by an easy and steady descent of the lever, avoiding any jerking motion, the piston can be brought down to the pressure or ram valve in the bottom of the pump chamber without reseating the piston valve, the liquid in the pump chamber passing back through the open piston valve, which has not been reseated, into the reservoir.

Having reached the bottom of the pump chamber with the piston head, a slight additional pressure of the hand upon the lever will open the pressure valve easily and the ram can be made to descend slowly or rapidly, or stopped entirely, as may be desired, by simply raising or lowering the lever. This careful opening of the pressure valve is not to be construed as a delicate operation nor, under any circumstances, approaching a tricky maneuver. The main feature of the movement is to avoid jerky movements or pushing the lever down on the pressure valves with sufficient speed to reseat them.

A well-known method of releasing the pressure is the use of by-pass holes, shown in Fig. 2. The liquid in returning to the reservoir passes around the piston (D) through these by-pass holes. In releasing the jack, the piston is forced down to the lower end of the pump chamber (B), where it thrusts the pressure valve from its seat, thereby permitting the liquid to pass through the ram or pressure valve back to the reservoir. When the piston is in this position the piston head is below the ports of the by-pass holes, so that the liquid in returning to the reservoir passes around the piston head through the by-pass. These by-pass holes entering the pump chamber at points over which the piston packing passes in making every stroke, act in much the same manner as a knife edge, and rapidly cut piston packing.

The use of by-pass holes decreases the upward speed of the ram, for when the piston packing passes the ports entering the pump chamber, the liquid remaining in the pump chamber is displaced through the unobstructed by-pass, instead of through the pressure valve. This loss, to be sure, is not a large amount, but, nevertheless, as such a small quantity of water is contained in the pump chamber with one full stroke of the piston, even a small deduction therefrom causes quite a difference in the speed of the ram.

In the jack shown in Fig. 1 the holes are eliminated, and the piston valve is forced off its seat by a small crosshead passing through the piston rod, thus returning the liquid to the reservoir through the same passages that are used in pumping the jack under pressure. This renders a smooth and unbroken surface in the pump chamber for the packing to pass over in its stroke, and the necessity for repacking the jack, while not entirely eliminated, is greatly reduced and the jack will remain in good order for a much longer period. Releasing the pressure through the piston valve passage also has the advantage of thoroughly washing the seat, and at times when a small piece of dirt lodges therein, the velocity of the returning liquid when conducted through the passage often displaces any substance of a foreign nature.

The use of the loose pump chamber, as shown in Fig. 2, also requires a soft ring packing (E) between the pump and pump plug, which, when employed, also requires a key (F) to keep the pump plug from turning and becoming loose. In the jack shown in Fig. 1 all this is unnecessary, and the pump plug is brought down to a solid metal surface at the joint (G), requiring no additional packing or keys.

HYDRAULIC WRECKING JACKS.—For wrecking purposes, where jacks are subject to very rough use and are constantly liable to be filled with sand or dirt, a very good form of jack is made similar to that in Fig. 1. Surrounding the cylinder (C) is a dirt shield secured in the head in the same manner as the ram (A). This shield, fitting closely at both top and bottom of the cylinder, rises with the ram and prevents exposure of the ram to dust and dirt. The head of the jack is provided with a slight extension, in order to contain sufficient liquid to pump the ram out of the cylinder its entire vertical stroke when the jack is in a horizontal position. Regular hydraulic jacks of the type shown in Figs. 1 and 2 will work horizontally about one-half the vertical stroke, the reason for this being that about one-half the liquid rests below the suction valve in the piston head and the pump acts only until the limit of submersion is reached. By placing a slight extension upon the head, more liquid can be introduced to offset this temporary loss of liquid caused by the jack being in a horizontal position. Upon the head of the jack an independent claw can be hung for lifting weights near the ground.

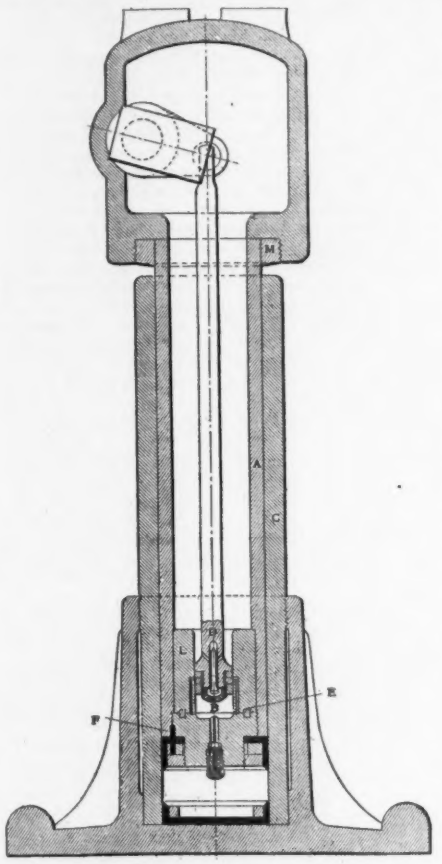

Fig. 2.—Hydraulic Jack.

In some shops, I have noticed the custom of grinding in valves with powdered glass, and while this may be effective as a cutting agent and serves to make a tight seat, still considerable care must be always exercised to remove every vestige of glass from the seats, else these small crystals will pass through the valves in pumping and cut the seats. Probably a better and safer cutting agent is flour of emery or crocus, which will be found finer in grain and more easily removed from the seat after it has served its purpose.

In taking a jack apart for any purpose, too much care cannot be used to keep all the parts clean. A good rule to follow is to have on the floor or bench a bucket of clean water, and as fast as small parts are removed place them in the bucket under water. Whether this rule is followed, or whether the parts as fast as removed are placed on the bench midst the ordinary shop dirt, all parts should be washed carefully before being replaced in the jack.

Frequently jacks are much injured by using impure liquid for filling. There have been many formulas tried and experimented with, but about the most successful is pure grain alcohol, two parts, with clean water, three parts. If the jacks are used in a warm or temperate climate, where the thermometer remains at 30° F. or higher, pure grain alcohol, one part, with clean water, four parts, will be found safe and satisfactory. The use of pure grain alcohol is recommended because of its anti-freezing properties, its beneficial effect upon the packings, and also for its light consistency. It never thickens, causing the valves to stick to their seats, and in a great degree retards the formation of rust. It is undoubtedly the best liquid for jacks known at the present time, although experiments are constantly being made to find an anti-freezing liquid that will not only be a preservative for packings, but will more completely act as a preventative of rust.

Wood alcohol and kerosene should never be used under any circumstances. If the jacks are being operated in an isolated country and the alcohol filling should be lost, it would be better to use plain water, provided the temperature was not below freezing point. The corrosive acids of methylic or wood alcohol will destroy the interior surfaces of the pump and cylinder and render the jack useless. Recently a new difficulty in liquid filling was reported to the writer by the engineer of track, N. Y. C. & H. R. R. R. Their custom was to keep the alcohol for jacks in galvanized iron cans and dilute it when used. A short time ago it was found the jacks were not working satisfactorily, and upon investigation it was found that the liquid was a strong zinc solution. Further inquiry revealed the fact that the alcohol completely dissolved the galvanizing in the interior of the can and caused a sediment in the liquid. This had a corrosive effect upon the valves and proved very unsatisfactory. Alcohol should be kept in tin cans and not in galvanized cans.

Kerosene oil will not injure the metal surfaces of the jack like wood alcohol, but will extract all life and vitality from the leather packings. I have seen packings taken from a hydraulic jack charged with kerosene oil which were so hard and brittle as to absolutely resist no bending strain applied to them without breaking short off, like a piece of thin wood. Experiments are now being made with a filling composed of oil and grain alcohol, which is calculated to remove the element of rust entirely and also to meet the other essentials such as a non-freezing liquid, and without deterimental effect to the packings.

HYDRAULIC TRANSFER JACKS.—A useful form of hydraulic jack for transferring locomotive driving wheels has been installed in many shops. The jack is operated either in or outside the roundhouse in a special pit built for the purpose. A transverse pit is made between two pits in the roundhouse for rolling the load from under the locomotive to the other pit, where the jack is again pumped up to the floor surface.

This form of tool is in use in some shops operated by pneumatic pressure; there are many shops, however, where the pneumatic system is not installed, and in such plants the hydraulic tool will be found very economical and desirable. The jack itself has a capacity of 15 tons with a stroke of ram of 54 ins. The pump is attached to the end of the reservoir and is made with a high and low pressure piston. This feature is desirable on account of the long lift to the ram which travels through a space of about 4 ft. without load, the speed of which is accelerated by the low pressure piston about four to one. When the ram has reached the point of contact with the load, a small clutch is turned about 25°, which disconnects the low pressure piston and at the same time places in action the high pressure piston, when continued pumping with the same lever carries the pressure up to the maximum capacity of the tool.

Four pair of drivers have been placed under a consolidation engine in 38 minutes by a gang of five men, and it is a common occurrence to run an engine in a roundhouse or shop in the morning after a regular trip, drop a pair of drivers, refit one or more new boxes and send the engine out on the regular afternoon trip without dropping the fire.

HYDRAULIC CRANK PIN PRESS.—Fig. 3 shows an improved type of portable hydraulic press for pressing in and out crank pins and such similar work. In the older designs of these presses the tension beam was placed at the rear end of the cylinder, but it was found in these types that the point of resistance at the rear beam being so far away from the point of contact at the ram head, a tendency was created to spring from a true line of strain and force the crank pin home out of true. In operating it is very similar to a horizontal jack. With the socket wrench the entire press above the trucks is elevated to suit the line of work. With the same socket wrench applied to the nut on the rack and pinion, the ram is forced out of the cylinder directly upon the work to be pressed, then with the pump lever inserted in the socket in the center of the press, the hydraulic pressure is exerted as high as may be desired up to the maximum capacity of the tool. The release of the pressure is accomplished with a small key wrench, and the release valve stem shown upon the end of the pump body to the right and slightly below the lever socket. The valves of the pump are made metal to metal, requiring no packing and are placed under the two bonnets just above the release valve, which makes them very easy of access and they can in a moment of time be taken out and examined, reground or renewed. The larger pieces of the press, especially the pressure cylinder, is made of steel, which not only lightens the weight of press thus rendering it more portable, but also admits of the cylinder being packed with a "U" packing in the throat. This "U" packing, in cases of this kind, is superior to the old form of cup packing in that it not only reduces to a minimum the friction on the ram, but also brings the wear of movement upon the ram instead of in the cylinder.

In cast-iron cylinders it is still the custom to use a brass or copper lining on account of the metal being of a porous nature; continual pressure permeates the body and eventually parts the casting, the lining also prevents the formation of rust. This system of lining cylinders has in many cases and for several causes proved unsatisfactory. Not only does the pressure at times, through the breaking of a bottom packing or some such cause, work in between the walls of the cylinder and the lining, producing a buckle therein, but it also necessitates the use of a cup packing on the end of the ram, which brings the wear of movement upon the cylinder, the most expensive part of the press. In using the steel cylinder and the "U" packing in the throat, there is no necessity to line the cylinder with brass or copper, for the packing, being in the throat or at the outer end of the cylinder, and being atmospherically tight, the element of rust formation is reduced to a very minute amount.

HYDRAULIC CAR WHEEL PRESSES.—The popular types of hydraulic car wheel presses are made with various modifications to operate with hand or power pumps, with pumps of various numbers and sizes of pistons, with driving mechanism at various angles to the machine, capacities, sizes, etc. A small vertical lever governs the movement of the ram. When in one position the ram is forced out at its low pressure or quickest speed, which continues until the ram comes in contact with the resisting force and the applied pressure reaches about one-fourth the maximum. At this point the automatic trip trips the low pressure piston with a steel rod passing through the suction pipe, forcing the suction valve off its seat. Thus the low pressure piston continues its stroke, but makes no delivery of water, while the high pressure piston continues the pressure up to the maximum, or until the desired limit is reached. When the applied pressure has gained the desired amount, the lever, upon being brought forward opens a patent double seat valve, which releases the pressure, and the ram is drawn back in the cylinder by the counterweight at the end of the press, the water returning to the reservoir through a return pipe shown in a vertical position at the back of the pump body.

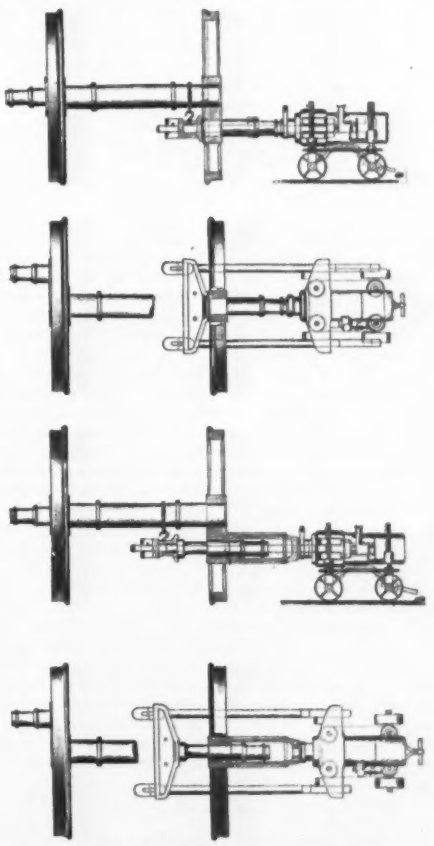

Fig. 3.—Hydraulic Jack for Crank Pins.

HYDRAULIC PUNCHES.—Fig. 4 shows a very useful tool in both bridge and shop work where occasion requires a portable tool for heavy punching. It shows the design of the pump and arrangement of valves, with the exception of the pressure valve, which is concealed behind the section line, the valves being laid out in the pump about 120° apart. The two valves shown in the sectional view are the suction and release. With the rack and

pinion the ram is brought down rapidly with one stroke until the punch rests upon the work, when a few strokes of the pump lever forces the punch through the piece. Turning the pump lever over and forcing the piston downward an additional stroke, as in a hydraulic jack, places in contact the shoulder shown upon the piston rod with the release valve, which is forced off its seat and the liquid is returned to the head or reservoir by driving the ram back into the cylinder with the rack and pinion mechanism.

The pump and head are made of a very high grade and hard bronze metal specially prepared for this purpose, and

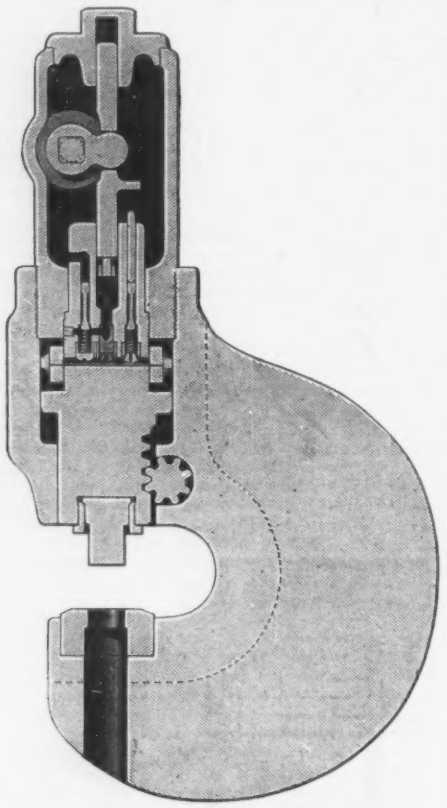

Fig. 4.—Hydraulic Punch.

the body is made of steel, which considerably reduces the weight and yet obtains the requisite strength.

Many modifications in the details of the jaw of this tool are made for a great variety of purposes, such as punching angles, tees, angle bars, I beams, T rail webs, etc., and the depth of jaw in the several designs varies from 1½ to 12½ ins.

HYDRAULIC RAIL BENDERS.—In the tool shown in Fig. 5 the pump details are the same as before, but the sectional view instead of showing the suction and release valves the same as Fig. 4, presents to view the suction and pressure valve, the release valve in this case being concealed behind the plane of section instead of the pressure valve. With the rack and pinion the ram is brought forward with one stroke of the lever in contact with the rail, when a few strokes of the pump lever makes the necessary bend in the rail. The ram is graduated to show the spring of the rail.

This bender is also capable of making very true curves, and does not in any case cock or twist the rail. Experiments have shown that it is not the method of bending the rail so much as it is the long or excessive space between the points of application, which causes the rail to spring out of true, and the best work seems to have been produced with a distance of about 24 ins. between the hooks. In one test two men bent 40 rails, 90 lbs. per yd., 30 ft. long, in one day, where 20 rails had been the best work of six men with the screw form of tool. One rail was bent to a 45-ft. radius in 1½ minutes.

THE DESIGN OF RETAINING WALLS.*

By Chas. Baillairge,† M. Can. Soc. C. E.

The city of Quebec is pre-eminently one of retaining walls, many of its streets having had to be supported on the downhill side to level them up to necessary grade. These walls have almost without exception been made unduly thin. The Des Carrieres St. wall of some 600 ft. in extent, in rear of Dufferin Terrace, erected about 60 years ago, under government control, stood for only 30 years, and was rebuilt again under government superintendence and at government expense. This second edition of the structure again gave way to the earth pressure in rear of it, and was rebuilt a third time within the last few years under the writer's direction as city engineer. The retaining wall of the old parliament site at the head of Mountain Hill has during the same period of 60 years been rebuilt not less than twice.

The same fate has overtaken the Artillery St. wall, the Dambourges St. wall, and most of those along the north side of Cote d'Abraham, and other streets, have had to be rebuilt, generally after a life of only 10 to 20 years or less.

The splendid cut stone retaining wall along Commercial St., Montreal, though built hardly 50 years ago, is and has been for some years back giving way, in like manner, from earth pressure in the rear, and the walls of the new Louise Docks at Quebec have already become disgracefully out of plumb and alinement from the same cause.

At the time of construction of the several walls mentioned it was supposed that as they had nothing to withstand but the pressure of so much dry earth behind them, they needed a base not greater than one-fifth to one-third their height, or sometimes even as low as one-seventh thereof, or about 3 ft. for a 20-ft. wall.

The fact was overlooked that the dry earth backing might become waterlogged by infiltration, especially so where no weepers had been provided for the removal of wet and moisture; or even with weepers, if the filling in their proximity was of too retentive or impermeable a nature, or where, in the case of weepers or no weepers, there had not been interposed between the back filling and the rear face of the wall a narrow space filled with loose material of a stony consistence to allow water, when reaching the wall, to run to the bottom thereof and thus find its way out or expend itself by absorption into the underlying soil.

The writer has noticed in very many cases of such retaining walls that the percolation into the embankment had waterlogged the filling, and thus caused it to press like a liquid against the wall, causing it to bulge or swell, and thus fail.

This waterlogging of the filling need not be permanent. It might recur at every heavy rain, and the wall each time be thrust forward by a fraction of an inch until its final destruction.

An unmistakable proof of this intermittent and instantaneous action of water is still to be seen along the rear face of Dufferin Terrace, Quebec, where, in an illustrated paper read before this society in the early '90's it was shown by the writer that an open fissure in the cliff in rear of the terrace had, under a persistent and heavy rain of several days' duration, in September, 1889, become filled with water, when, due to the thrust from the rear, an outward portion of the cliff fell forward with the destruction of much property and the loss of some 52 lives. The crevasse alluded to, thus filled with water to a depth of over 100 ft., exerted a hydrostatic pressure which pushed the intervening rock forward some 6 ins.

In addition to this action of a fluid or waterlogged substance against a retaining wall, there is also, in this climate, the yearly action of frost, which, expanding the back filling, as water does in freezing, also pushes a wall forward, and though but as little as the eighth or even the sixteenth part of an inch at a time, in course of years effects its overthrow.

It is therefore seen that all retaining walls are liable to become like dam walls, which have to stand the pressure of water, and that as such, the same rules as to strength and thickness should apply.

Also that where ice may form in rear of a wall, and where this ice in forming cannot spend its effort on compressible material towards the rear, the whole effort is then against the wall, and, if repeated from year to year, the wall must go, as nothing can withstand the effect of ice expansion. The only safeguard for the retaining wall in such a case is to so roof in or impermeably cover the surface of the back filling with asphalt or other watertight substance, that no water can get at it, or penetrate the soil in rear of the wall in a way to run the risk of any ice forming.

*From a paper read before the Canadian Society of Civil Engineers, Jan. 3, 1901.
†Quebec, Canada.

ABSTRACTS OF PAPERS PRESENTED AT THE MEETING OF THE ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.

At the annual meeting of the Illinois Society of Engineers and Surveyors, held on Jan. 23, 24 and 25, at Bloomington, Ill., papers on "Modern Brick Pavements and Gravel Roads," and one describing the "Results of the License Law for Architects in Illinois" were read, from which we abstract the following items of most general interest:

MODERN BRICK PAVEMENTS.

By. W. H. Tarrant.*

In grading, where excavation is necessary, no pit should come nearer than 3 ins. to the finished subgrade; hand tools should be employed in dressing off this 3 ins. or more. The filling should be done in layers not exceeding 4 ins., each well sprinkled and rolled, with all soft places filled with rolled gravel. The surface at subgrade should be rolled by a roller at least 5 ft. wide and weighing not less than 250 lbs. for each inch in width. No loaded or empty wagons should be allowed upon the subgrade, after rolling, unless this surface is protected by boards. Paving material should be placed along the line of the work before the completion of the subgrade.

The cross-section of the street should be parabolic in form; and the writer has used the following formula with excellent results: Where c = crown of the street and w = width of street in feet; $c = 0.014\ w + 0.03$. The constant 0.03 is added to the middle ordinate of the street so as slightly to elevate the center and thus avoid a flattened place in the street.

The gutter should be 18 ins. wide and the curb be 5 ins. thick for a 36 ft. street; both made of concrete. The gutter should have a slope of 1 in. toward the curb, and the curb should be 7 ins. high above the gutter, and the upper face-edge of the curb and its juncture with the gutter should be curved, with a radius of 1¼ ins. The gutter should be 6 ins. thick, and the construction should be such as to make a solid mass of both gutter and curb; 1 part Portland cement and 5 parts clean gravel being used.

For the foundation of the gutter and curb, use 6 ins. of gravel or cinders, well damped and thoroughly tamped with a tamper having a face-area of not less than 36 sq. ins. and weighing not less than 30 lbs. The finishing coat should be 1 in. thick and be made of 1 part Portland cement to 1½ parts of clean sharp sand; and this coat should be put on before the concrete has commenced to set. This concrete curb and gutter should be laid in alternate sections, and in lengths of 7 ft. It should be protected from the sun by a canvas covering for at least 24 hours; and in extremely dry weather the concrete should be sprinkled at least once a day for several days. The catchbasin inlets should be built with the curbs, and the best form is a corner inlet with vertical bars, which will never be clogged by leaves and rubbish.

For the concrete foundation of the pavement use 1 part American natural hydraulic cement to 2 parts clean sharp sand and 4 parts of broken stone. With Portland cement, the proportions can be 1, 3 and 6 parts; with gravel as a substitute for broken stone, 1 part Portland cement to 8

*City Engineer, Champaign, Ill.

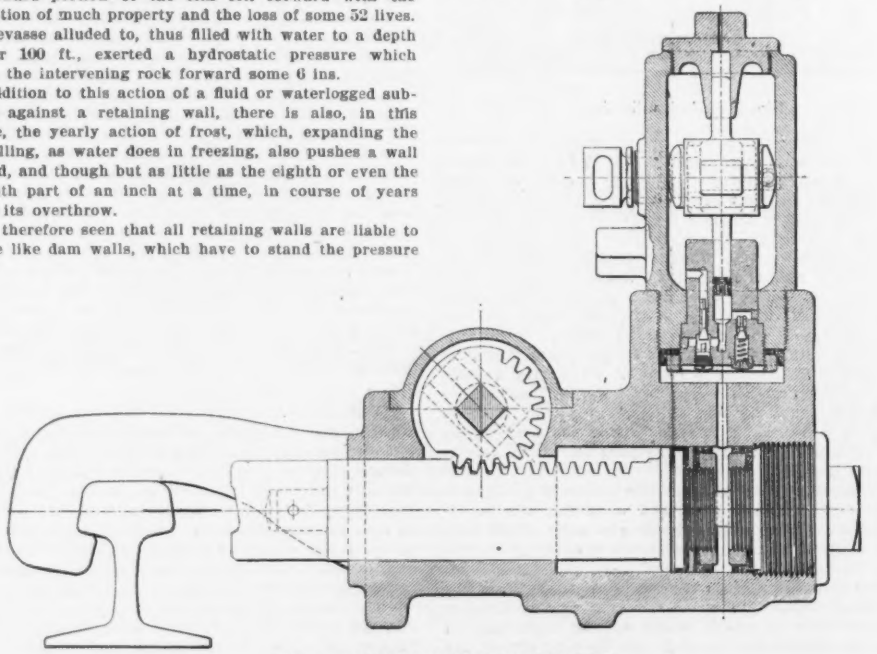

FIG. 5.—HYDRAULIC RAIL BENDER.

parts gravel. This concrete should be 6 ins. deep and 6 ins. thick under the bottom of all ties of street railways. Mix the sand and cement thoroughly, add water to give it the proper consistency, then add broken stone; mix three times and finally shovel it into the work. The concrete should be well tamped with a 30-lb. tamper, and having an area of at least 25 sq. ins. All hollow places, after tamping, should be filled with cement mortar and again tamped with an oak tamper of 18 sq. ins. To give the concrete surface the proper crown, set a line of stakes, 3 ft. apart, along the street center, and use a template, reaching from this stake to the curb, to set a line of stakes perpendicular to the curb and 3 ft. apart.

The cushion of clean dry sand should be 1¼ ins. thick, and this sand should be exactly graded by a template resting on strips in the middle of the street and on the curb. The bricks should be laid in rows perpendicular to the curb, except at street crossings, where they should be laid at an angle of 45°. There should be the least possible space between these bricks as laid. Where there are street railways, lay the brick between the rails parallel to the rails, with one parallel row outside the rails. When a 6-in. T-rail is used, lay the first row on the inside flat, and the others on the edge. A brick pavement should be rolled parallel to the curb, commencing at the center of the street. The roller should not weigh less than 200 lbs. to the inch of width, and the pavement should be rolled at least three times.

If the bricks are standard bricks and not repressed, sand makes the best filler, but for repressed brick Portland cement should be used. The repressing of bricks tends to destroy the bond given to the clay in the brick machine, and the later pressing does not put pressure enough upon it to make a new bond. The writer condemns the practice, and says that repressed brick scale off at the edges.

The sand used for a filler should be clean, sharp, fine and dry; it should be applied in thin layers and well broomed in with steel brooms. With all spaces filled a ½-in. layer should be left on the pavement. If grout is employed, it should consist of 1 part Portland cement and 1 part clean sand, both mixed dry and then watered until it has the consistency of thick cream. When this grout is poured on the pavement from the grout boxes it must be thoroughly broomed into all interstices and applied in two courses, the second being a little thicker than the first. With joints all filled and the cement set for a few hours, a coating of sand is put over it to protect it from the wind and sun. All grout should be allowed 7 to 10 days for setting before the street is opened to traffic.

RESULTS OF THE LICENSE LAW FOR ARCHITECTS IN ILLINOIS.

By. N. Clifford Ricker.*

While in New York, Ohio, Missouri and Texas attempts have been made to enact a law licensing architects, Illinois alone has passed such a law. This law, based upon a draft made by a committee of the American Institute of Architects of Chicago, was passed in 1897 (see Engineering News, of Oct. 21, 1897), and some defects in it were remedied in 1899.

The chief features of this law are as follows: A practicing architect must procure a license, obtain a personal seal bearing his name and address, and impress this seal on all working plans and specifications sent out. This license may be revoked for non-payment of annual fee, and for incompetence, recklessness or dishonest practices, after due trial before the board. For practicing without a license the penalty is from $50 to $500 per week, the penalties going to the school fund.

To avoid strong opposition, any person practicing architecture on July 1, 1897, when the law went into effect, was entitled to a license without examination. As a result a considerable number of incompetent men were licensed. After Jan. 1, 1898, careful examination for fitness and experience was required, and nearly one-sixth of the entire number of architects on the list have been thus replaced by younger and more competent men within the past three years, and at the end of 15 years it is expected that only properly licensed and qualified architects will remain.

To avoid opposition from large contractors, who commonly furnish their own plans and specifications with the bid for the work, this was permitted by the law, without using a license or seal. But when such plans are offered for bids from others, and the work is let to another contractor, the author of the plans becomes an architect practicing without a license, and is liable to penalty. This permissive clause of the law is practically made inoperative by the fact that an ordinance has been passed which authorizes the issue of building permits only for plans stamped by a licensed architect; and this ordinance practically compels all those erecting their own buildings to employ a licensed architect. The old provision in the law should now be cancelled.

The law does not prevent non-resident architects from practicing in Illinois, for these may obtain licenses on exactly the same terms as residents of the state, and a number have done so.

*Professor of Architecture, University of Illinois.

The Board of Examiners appointed by the Governor consisted of Dankmar Adler, President for two years; Peter B. Wight, Secretary, and W. H. Reeves, W. C. Zimmerman and N. C. Ricker. This board sent out blank forms to be filled out by the applicant and sworn to, and to check the statements made, two buildings had to be named on which the architect was employed, with the names of owners. The answers received fixed the fact whether the applicant was really the architect or only the contractor for building. Of the 800 applications received about 700 were granted, and more than 500 of these were issued to architects practicing in Chicago or its suburbs. One Bohemian architect was found who was actually using specifiations written and printed in the Bohemian language.

After Jan. 1, 1898, a new form of application blank was used, and the license itself stated that its possessor had passed a satisfactory examination as to professional fitness. Up to the present time, out of 186 applications for examination 120 have been licensed. A total of 820 licenses have thus been issued in Illinois, and about 670 of those are now in force, showing a loss of 150 by death, removal from the state, or abandoning the profession, but chiefly by the revoking of licenses for non-payment of fees. One license has been revoked for dishonest practice. This license law is enforced by the attorney of the Board, Mr. Charles N. Goodnow, of Chicago.

The general results of the law have been decidedly advantageous to the public and to the profession. Incompetents have been driven out of the business, the professional status of architects has been very materially raised, and the general public is learning that there is a great difference between the architect and the contractor. The professional education and training necessary to the successful practice of architecture has also been increased in volume and quality since the law went into effect. Two important changes are noticed: The country practice is rapidly passing into the hands of local instead of Chicago architects, as formerly. Secondly, with the exception of great office and mercantile buildings—still monopolized by a few Chicago firms—the work of the profession is rapidly passing into the hands of younger men, whose education, training, opportunities for travel, etc., are far superior to those of their predecessors.

GRAVEL ROADS OF McLEAN COUNTY, ILL.

A. H. Bell, C. E.*

The soil over which we have to build roads in this county is either a black loam or yellow clay, the former predominating. Either of the soils will readily become soft and yielding under the influence of frost and water.

There are but three townships in McLean county that have made any material progress in the line of hard roads. Lexington township, in which is situated the town or village of Lexington; Cheney's Grove township, in which is situated the town of Saybrook, and Bloomington township. There are probably some other isolated pieces of hard-road construction in the other townships, but they are of small magnitude and of the same general construction as those hereinafter described.

LEXINGTON TOWNSHIP.

Lexington township, lying about 15 miles northeast of Bloomington, has about 22 miles of gravel roads radiating from the town of Lexington.

The roads are constructed under the supervision of the highway commissioners, of which there are three in each township. Their general construction is as follows: The gravel is hauled by teams from the bank and deposited three loads side by side, about 12 ft. wide, which when spread out and leveled off, makes a roadbed of 15 or 16 ft. in width and 10 to 12 ins. in depth in the center. It requires about five loads of gravel to the rod. The cost of building the gravel road is, of course, more or less regulated by the proximity of the gravel bed. That constructed during the past year cost on an average about $1,200 per mile, wherein the haul was about three miles; cost of hauling gravel 60 cts. per cu. yd. and 10 cts. per cu. yd. at the bank. In general terms the gravel roads of Lexington township cost from $1,000 to $1,500 per mile, as regulated by the proximity of the gravel pit.

The items of tiling and grading do not enter into this estimate, as this has generally been done (where deemed necessary) in previous years. The roads are generally graded more or less by the road grader and no special grading is resorted to as a preparation for the gravel. The general practice is to place the gravel road rather to one side of the highway, thus leaving a dirt road to be used when in proper condition, which is a very large portion of the year. I regard this as a very essential and important feature of gravel road construction in this country.

The oldest gravel road in Lexington township has been in use about 16 years, and is still in good condition. It is necessary to do some repairing each year, putting in a few loads of gravel where depressions may develop; but the expense of maintainance is very small and much less than in the ordinary dirt road.

There is a special tax levy in this township for building hard roads of from 20 cts. to 60 cts. per hundred dollars. Gravel is to be had in abundance in this township.

CHENEY'S GROVE TOWNSHIP.

In this township they claim to have about 7¼ miles of gravel road. The gravel is first laid about 8 ft. wide and 14 ins. deep, requiring about 5 yds. to the rod. The cost of hauling and distributing the gravel is given at 33⅓ cts. per cu. yd. or load; the material costing 5 cts. per cu. yd. at the bank, and the haul averaging about 1½ miles. This would make the road cost about $600 per mile. They make no special tax levy for hard roads in this township, but build such as they can each year from the special road and bridge tax. The oldest gravel road in Cheney's Grove township has been in use about 14 years, and is still giving good service. Where the width of the highway will permit the gravel bed is placed to one side of the road, leaving the dirt road for seasonable weather.

BLOOMINGTON TOWNSHIP.

Bloomington township, the wealthiest in the county, has but recently experimented with the hard-road question. This is probably due largely to the fact that gravel in this township is difficult to get, unless transported. However, recently an appropriation of $21,800 was voted by the township to apply to the construction of hard roads. It was contemplated to build three miles leading west from the city limits on West Washington St.; also three miles leading south on South Main St. Owing to the amount of grading and the expensive material, the appropriation was only sufficient to construct about 2 miles west of the city and about 1.37 miles south of the city, making a total of 3.37 miles. The cost of construction exceeded the appropriation about $1,195, making a total cost of $22,995, or about $6,823 per mile. The grading and tiling in the roads cost approximately $4,500. The material used for the roadbed was novaculite* or clay gravel from the vicinity of Cairo, Ill. A distinct channel was formed 12 ft. wide and 8 ins. deep, in which the novaculite was placed and afterwards rolled with a six-ton roller. The cost of the novaculite was 75 cts. per sq. yd. laid down.

As to the merits of novaculite for hard roads on our soil, there is at this time much diversity of opinion. The short time it has been down here does not justify us in either condemning or recommending it. The writer, however, has had considerable experience with the material in Cairo and suburbs and can, therefore, speak from some personal observation.

Where the roadbed is kept clean from mud it proves a very satisfactory and durable article. The top surface grinds into a dust, which upon the application of water or rain has the property of cementing and becoming very compact and hard, also quite smooth. But if mud is allowed to accumulate on it or teams come onto it from mud roads, it will "pick up" and become full of holes and sinks, even worse than macadam. This is especially the case when the pavement is of recent construction and has not become thoroughly compacted and solidified.

I do not regard novaculite as much superior to a good quality of gravel for hard roads in this locality. What we have has been laid at great expense. We hope it will prove a great success, but its great cost will exclude its further use in this locality.

The gravel roads as described in the two townships above are a success and give universal satisfaction. This is attested by the fact that more miles of gravel roads are being added each year in the townships quoted, which is an endorsement of the procedure beyond question. The method of construction of gravel roads in McLean county has been somewhat primitive, no doubt, and in all respects an air of economy has pervaded the minds of the highway commissioners. I am not aware of the services of an engineer being engaged in their construction, either in tiling or preparation of the roadbed.

There is no doubt in my mind but that the services of a good, practical and experienced engineer would add to their general benefit, and very materially to their sightly appearance. But the highway commissioners are generally selected from the farming community, and they only employ a surveyor or engineer as they do a doctor or lawyer—in self-defense. But this will change with time and education. Certain facts seem to have become established from our experience of building gravel roads in McLean county. (1) They are a success from a financial and economical standpoint. They afford a very satisfactory basis of transportation at any and all seasons of the year. They enable the farmer to deliver the products of his farm to the highest market afforded, and they reduce very materially the annual expense of the road grader and other repairs on the common dirt road. (2) Our experience has developed the fact that gravel has proven so far the most desirable material for a roadbed in this locality. (3) The gravel bed should be laid to one side of the road. (4) The roadbed should be thoroughly tiled or drained before laying gravel. (5) The quality of gravel giving the best results is a clean gravel (free from mud or clay), with about 25% of sand to act as a binder; in general this gravel should not exceed 1 in. in diameter. (6) The cost of maintenance is very light when properly constructed.

*County Surveyor, Bloomington, Ill.

*A very silicious variety of clay slate, according to the Century Dictionary.—Ed.

PLANT FOR INVESTIGATING THE PURIFICATION OF MISSISSIPPI RIVER WATER AT NEW ORLEANS.

Through the courtesy of Mr. Geo. G. Earl, M. Am. Soc. C. E., General Superintendent of the Sewerage and Water Board of New Orleans, we are enabled to present an illustrated description of the plant recently installed in that city for investigating the very serious problem of converting water from the Mississippi River into a suitable supply for the varied wants of a large city. The plant includes four rectangular settling and three coagulating tanks; two mechanical filters, a slow sand filter, and a modified slow sand filter, the latter receiving water which has been treated with a coagulant; a clear water tank; a chemical and bacterial laboratory; besides a pumping plant and various accessories.

A general view of the plant is shown by Fig. 1, and a general plan by Fig. 2. An end elevation is given in Fig. 3, while Fig. 4 is an interior view.

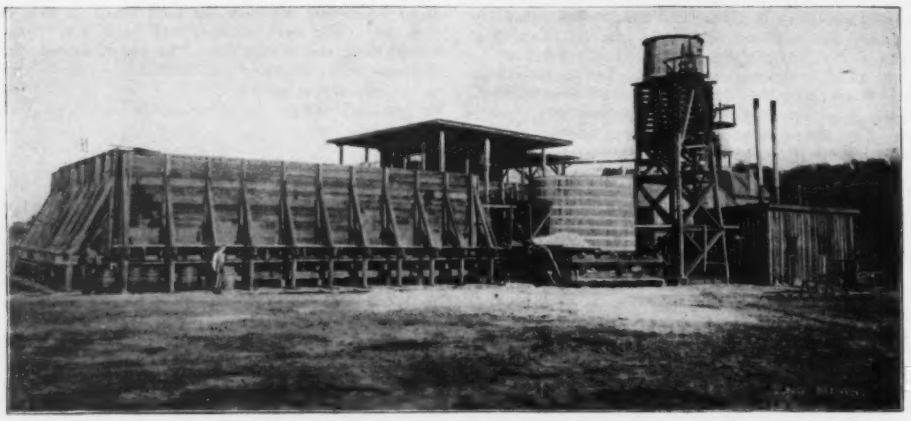

FIG. 1.—GENERAL VIEW OF PLANT FOR STUDYING THE WATER PROBLEM OF NEW ORLEANS.

A more detailed description of the plant is given below, as sent us by Mr. Earl, on Jan. 28:

The sedimentation tanks are of pine lumber, lined with tongued and grooved ceiling. When they were first filled the leakage was very considerable, taxing the capacity of the little pump required to fill them. The swelling of the wood, as expected, aided by the silt in the water and a few pounds of corn meal and sawdust, soon reduced this leakage to a reasonable amount.

The sand filters and clear water tank are circular cypress tanks, and the laboratory, boiler house and pump house are of rough pine construction. The entire woodwork of sedimentation tanks, sand filters, clear water tank, laboratory, boiler house and pump house, etc., cost about $6,000, and the mechanical filters, piping, boilers, pumps and machinery generally, including the laboratory equipment, cost about the same amount.

The total capacity of the sedimentation tanks is 207,000 gallons, and the four systems of subsiding basins and filters have a combined capacity of 93,000 gallons per day, as follows:

(1) Three days of plain subsidence for 12,000 gallons, and then filtration through 5 ft. of fine sand.

(2) Two days of plain subsidence and one day of auxiliary subsidence with coagulation for 9,000 gallons, followed by filtration through 3 ft. of coarser sand.

(3) Two days of plain subsidence and 12 hours of auxiliary subsidence with coagulation for 36,000 gallons, followed by filtration through a 4-ft. Continental gravity filter, which has an air blower to mechanically agitate the sand during washing.

(4) One day of plain subsidence and 12 hours of auxiliary subsidence with coagulation, followed by filtration through a 4-ft. Jewell gravity filter, which has the regular mechanical device for the agitation of the sand layer during washing.

The work of the force under Mr. R. S. Weston, Resident Expert, consists in the operation of this plant in such a way as to determine as definitely as possible every fact which can be obtained therefrom that will have a bearing upon the problem of the proper design and operation of the ultimate purification plant for New Orleans.

The chemical and biological conditions of the water in each system and at every stage of it are recorded, together with all data as to length of runs, cleaning of filters, etc.

The force under Mr. Weston consists of one engineer, three analysts, two filter attendants and two laborers. The plant is being run continuously day and night, and it is intended to operate it at least long enough to cover the entire round of changes which are presented during the river year.

The slow sand filter (No. 1) contains 5 ft. of 0.21-mm. sand, resting on 7 ins. of graded gravel. It is rated at 100 mm. per hour, or 2,560,000 gallons per day. Filter No. 2 contains 3 ft. of 28-mm. sand, also on 7 ins. of graded gravel. It works at double the rate of No. 1, but the applied water has first been treated with a coagulant. Each mechanical filter contains 4 ft. of 0.32-mm. sand, resting on 4½ ins. of fine gravel.

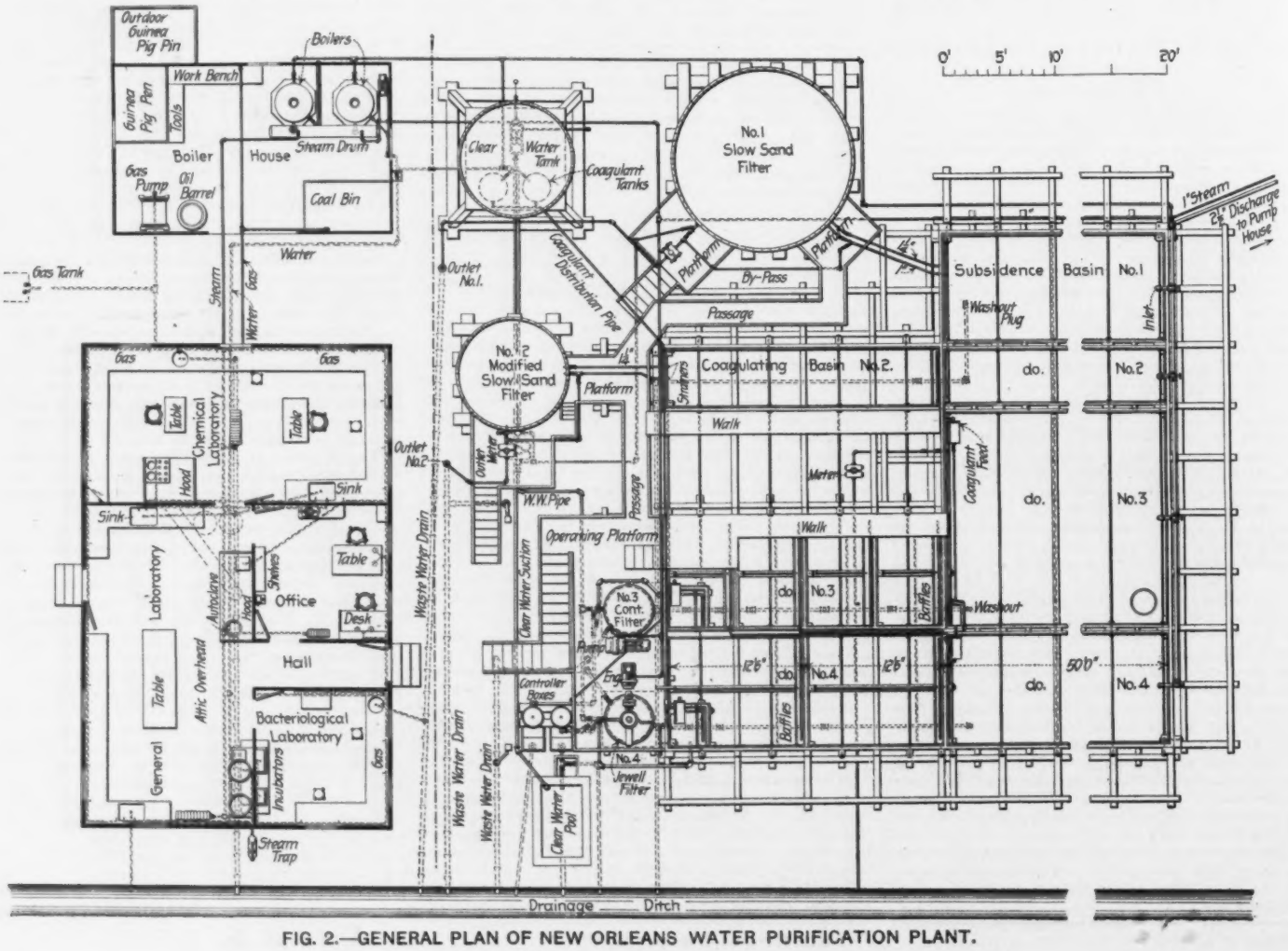

FIG. 2.—GENERAL PLAN OF NEW ORLEANS WATER PURIFICATION PLANT.

REPORT ON THE ABOLITION OF GRADE CROSSINGS AT CLEVELAND.

The abolition of grade crossings in Cleveland, O., has been made the subject of a report by a special committee of the Cleveland Chamber of Commerce, with Mr. J. H. Sheadle as chairman. The

committee finds that there are 135 crossings of steam railways with streets at grade, of which 29 are in streets bearing street railways, another 29 are on main streets without surface railways, and the remaining 78 are on streets with comparatively light traffic. The result of observations made at three important crossings are given in the report in the form of a census, by hours, and for 24 hours of one average day. At the combined Euclid Ave. and Wilsson Ave. crossing it was found

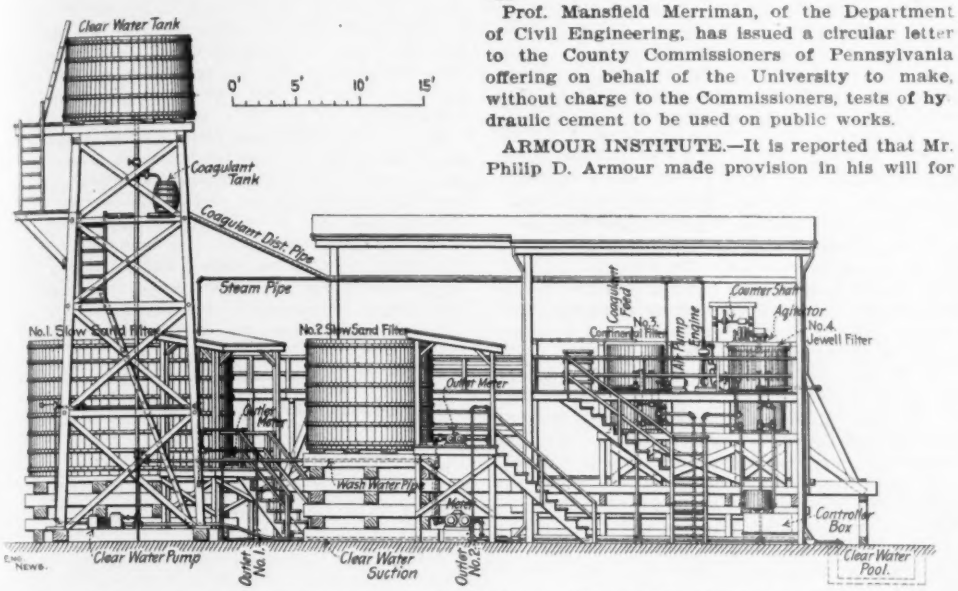

FIG. 3.—END ELEVATION OF NEW ORLEANS WATER PURIFICATION PLANT.

that during 24 hours 9,831 pedestrians crossed the railway tracks; also 6,020 ordinary vehicles and 1,303 street cars, the two classes of vehicles containing a total of 33,119 passengers. Delays caused to pedestrians and passengers were noted and it was concluded that for this combined crossing:

Each street railway car is delayed half a minute on account of the crossing, either on the Euclid or Willson lines, during an average day of 17 hours; and 100 trains delay traffic a total of 2 hrs. and 18 mins., or 1⅛ mins. per train. It is thus found that 1,207 pedestrians, 740 vehicles and 4,068 passengers were delayed 1⅛ mins. each on account of trains, at a cost of $19,964; also that 33,119 passengers were delayed one-half minute each, at a cost of $27,654; a total cost of $47,618 per day, which in one year amounts to $17,380.57, or 5% on about $350,000.

The delays at the other two crossings, when capitalized, would warrant the expenditure of $106,000 for Detroit St. and $142,500 for Pearl St.

Under existing laws, railway companies in Ohio cannot be compelled to abolish grade crossings, but in case an agreement for such action is reached the law requires steam railways to pay not less than 65% of the cost and prohibits municipalities from paying more than 35%. Street railways are not ocmpelled to pay a cent. In conclusion, the committee submits the following recommendations:

(1) That the legislature be requested to pass a law requiring street railroads to pay not less than 25% of the expenses of abolishing grade-crossings used by them.

(2) That the legislature also be requested to pass a law providing for the appointment of a grade-crossing commission, to be composed of the Governor, Auditor of State and Commissioner of Railroads, who shall have authority in event of its satisfactorily being made to appear to them that a municipality has been unable to agree with any railroad company with respect to the abolishment of its grade-crossings, to determine, after full hearing being given the parties interested, as to the necessity of abolishing such crossings and as to the terms and conditions upon which the same should be done, including the apportionment of the cost thereof upon the parties interested.

(?) That the Mayor be requested to appoint a committee of seven representative citizens, who shall serve without compensation, to consider and report plans for the abolishment of all grade-crossings in this city, and to confer with the proper representatives of the various steam and street railroad companies with a view to inducing them to agree upon the adoption of mutually satisfactory plans and to contribute their just proportion of the cost of making such improvements.

(4) That to pay the legitimate expenses of such committee, including the expenses of employing competent engineers to make the necessary surveys and prepare plans and estimates to that end, the council be requested to appropriate the sum of $10,000.

NOTES FROM THE ENGINEERING SCHOOLS.

LEHIGH UNIVERSITY.—Mr. Warren A. Wilbur, of South Bethlehem, Pa., has made a gift of $5,000 to the University for the purchase of apparatus for a mechanical laboratory. This laboratory will be installed in the new building of the department of physics and electrical engineering.

A geological laboratory for the microscopic study of rocks has been equipped by Prof. E. H. Williams of the Department of Mining and Geology.

Prof. Mansfield Merriman, of the Department of Civil Engineering, has issued a circular letter to the County Commissioners of Pennsylvania offering on behalf of the University to make, without charge to the Commissioners, tests of hydraulic cement to be used on public works.

ARMOUR INSTITUTE.—It is reported that Mr. Philip D. Armour made provision in his will for an endowment of $1,000,000 for the Institute and that the latter will be affiliated with either the University of Chicago or Northwestern University.

UNIVERSITY OF PENNSYLVANIA. — The University has recently received a gift of $100,000 as the bequest of the late Jane Eleanor Welton, of Waterbury, Conn. The gift is to be used for the establishment of a Museum of Science.

CORNELL UNIVERSITY.—The faculty of the University is discussing the subject of establishing a college of commerce and industry, in which men may be trained to carry on consular work abroad and administrative work in the new dependencies, as well as to make more efficient agents for the extension of business into new countries. An additional expenditure of $5,000 a year, it is said, would be ample to carry out the project.

UNIVERSITY OF TEXAS.—The students in engineering have lately organized an Engineers' Club, which meets twice a month.

NEW YORK UNIVERSITY.—Many additions have recently been made to the Museum of Economic Geology. Mr. Andrew Carnegie has donated a complete series of ores representing his mines in Michigan and Minnesota, including the "Norrie," "East Norrie," "Pioneer," "Virginia," "Mountain Iron" and "Zenith.' The museum already had a fine series of micaceous ores from Michigan, and this very extensive contribution makes the collection of Michigan and Minnesota ores nearly complete. Mr. John D. Archbold has given the museum a series of crude petroleum samples from Japan, Borneo, Sumatra, Java, India, the Red Sea, Zante, Argentina, Galicia and Elsass, illustrating the types found in those countries. This is in addition to a previous gift of samples of petroleum from 60 American localities. The museum had already more than 300 samples from the Stevenson collection.

THE CANADIAN STEEL CO., with $90,000,000 capital, was organized lately in London, according to a press despatch from that city. It is said to be the project of Mr. E. M. Butz, a mechanical engineer of Pittsburg, Pa., who is its chief engineer. The company is reported to have secured 5,000 acres of land in the town of Welland, on the Welland Canal; and is to there erect blast furnaces and a complete steel plant of 2,000 tons daily capacity. The purpose of the company is to take advantage of the Dominion bounty of $3 per ton on pig iron, and $3 per ton on all steel made from Canadian ores. The Ontario government offers an additional bounty of $1 per ton on steel. The company owns ore lands in Northern Ontario, and will haul its coal from the neighborhood of Pittsburg and make its own coke.

THE SOUTH CAROLINA INTERSTATE AND WEST Indian Exposition will be held in Charleston, S. C., from Dec. 1, 1901, to June 1, 1902. Contracts have been let for erecting four of the principal buildings and construction is now in active progress. There will be eleven buildings in all. The manufacturing industries of the South will form an especial part of this Exposition, as the most improved machinery is now in demand. The investment in manufacturing enterprises already exceeds $1,000,000,000 in Southern states. Mr. J. C. Hemphill, Charleston, S. C., is the Manager of the Department of Promotion and Publicity, and will answer all inquiries as to the scope of the Exposition.

THE COINAGE RECORD FOR 1900, says Mr. George E. Roberts, Director of the Mint, exceeds that of any year in the nation's history. It aggregated $141,351,960; of this the gold coinage was $107,937,110; silver dollars, $18,204,984, and the subsidiary silver coinage amounted to 57,114,270 pieces, valued at $12,876,849. The copper and nickel pieces numbered 101,301,753 pieces, valued at $2,243,017. The coinage aggregate for 1899 was $136,855,676.

THE MASSACHUSETTS TOPOGRAPHICAL COMMISsion, in its late report to the governor, estimates that it will require about eight or ten years more to complete the topographical work in the state. Mr. Desmond Fitzgerald, Past President of the American Society of Civil Engineers and Chief Engineer of the Metropolitan Water Board, is one of the members of this commission, and the others are Mr. A. E. Burton, of the Massachusetts Institute of Technology, and Mr. Frank W. Hodgson, engineer of the Harbor and Land Commissioners. This commission serves without pay. Massachusetts is the first state to undertake this work on so complete a scale, and the value of the

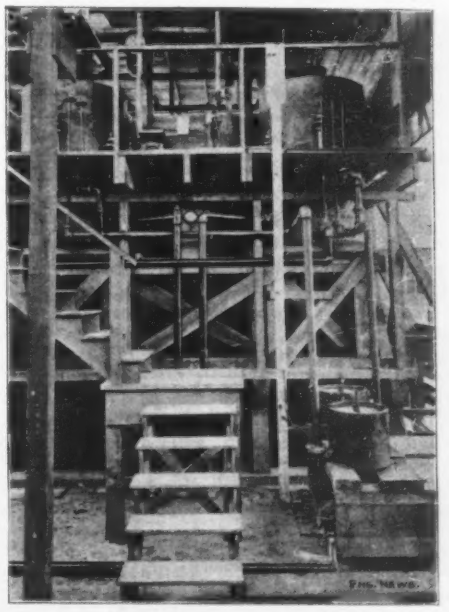

Fig. 4.—Interior View of New Orleans Water Purification Plant, Showing Mechanical Filters, with Controllers Below.

work is undoubted. It has already determined many vexed questions of boundary lines and stopped disputes. They are also marking the boundaries between Massachusetts and New York and Rhode Island.

A SWEDISH WATER-POWER COMMISSION has been appointed by the government to investigate all the water-powers in Sweden which may be located near possible lines of railway that would not be remunerative if worked by steam. This commission has already recommended the passage of a law making these possible sources of power national property, to be utilized for generating electricity for industrial purposes. Meanwhile Dr. G. de Laval, the well-known turbine inventor, is trying to form a trust of all the Swedish water power, to be worked for the mutual benefit of the owners. As many of these falls are frozen in the winter period, there is trouble in adjusting this condition to industrial needs; the use of large storage battery plants is being investigated.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The brief and sensible paper on the design of retaining walls, by the former City Engineer of Quebec, which we print in another column in this issue, tells nothing that will be particularly new to engineers experienced enough to have witnessed the "decline and fall" of such structures; but it may give some valuable ideas to some of the younger members of the profession whose knowledge of retaining wall design are based on the mathematical discussions in their text books. With a hypothetical material behind a wall, the mathematician can compute what the pressure upon the back upon it will be, and the thickness which will enable the wall to withstand this pressure with a given factor of safety; but the futility of finespun computations become apparent when we substitute the actual material behind the wall for the theoretical, and consider that its character continually changes with the changes in moisture and temperature that every changing season brings. Good drainage can add more years to the life of a retaining wall and save more cubic yards of masonry in its construction than any other thing in connection with it. In fact, it may not be far wrong to say that there is more need of good engineering in placing the filling behind the wall than in building the wall itself.

The brief paper in another column describing experience in Australia in the use of steel and concrete cylinders to protect piles against the teredo and for the formation of cylinder bridge piers should be of much interest to American engineers. None of the ordinary methods of protecting piles against the teredo can be said to be so satisfactory that something better, cheaper and more durable is not worth consideration. The chief objection which may be brought, we presume, against the Monier construction when immersed in water is that the water may percolate into the concrete and corrode the steel. The Australian engineers seem to have concluded (on what appears to be rather doubtful evidence) that no danger from this source need be apprehended. It is probably true that concrete is a better protection from corrosion than anything else with which steel can be covered; and where air exposure alone is concerned, it may be considered a perfect protection. Where a concrete and steel construction is placed below the water line, however, the well-known porosity of concrete seems sufficient indication that corrosion of steel imbedded in it must ultimately occur, and corrosion of any considerable amount must inevitably cause an expansion which will fracture the concrete.

An illustration of the expansive force of corroding iron was recently noted by a member of the staff of this journal, near a well-known fortification on the Atlantic coast. Some very heavy granite blocks, which had bolts passing through them, had been removed from their original position in the work and lay exposed to the weather. In each case these blocks were cracked clear across through the bolt-holes, the crack showing every evidence of having been produced by the expansive force of the rust on the bolt.

We do not say, of course, that rapid action of this sort is to be expected where steel is imbedded in well-made concrete; but it seems probable that something of the sort may eventually be expected where such constructions are immersed in water.

We refer to this matter, not as an argument against the applications of Monier construction which have been made in Australia, as above noted; but as something to be borne in mind in carrying out such work. In very many places where piles have to be protected from the teredo there is no advantage in using a protective covering which will outlast the pile itself. As for the use of such pipes for cylinder bridge piers, the real strength of such a pile is its concrete filling; and the concrete and steel shell would very likely last as long or longer than the steel plate cylinders commonly employed.

It may well be doubted whether any more beneficent action has been taken by the United States Government during the past quarter century, or any which will be more fully justified by future results than the establishment of national forest reservations. It is probably true that some mistakes have been made in their administration; and there is no doubt at all that such action interferes with the present profit of a few, who want to destroy these remaining forests for the gain they can make; but the very idea of such reservations is that some present sacrifice is to be made for the sake of large future gains.

Thus far, all these reservations have been made from lands already owned by the Government and all of them are located in the far West. There is now a movement on foot, however, for the establishment of a great national park and forest reserve in the Southern Appalachian range, about the region where the four States of Georgia, Tennessee, and the Carolinas come together. Here are located the highest peaks of the Appalachian range, and the largest area of untouched forest probably, east of the Mississippi. In this region are the headwaters of many of the principal Southern rivers, and the stripping of these steep mountain slopes of their forest covering cannot but have a serious effect upon the flow in these streams. Besides these considerations, the value of such a great public park as a resort for health and pleasure is beyond question; and while Congress would not be justified in undertaking such an enterprise for this reason alone, this factor certainly deserves to be given some weight.

It is true that the land for such a park or preserve would have to be purchased from private owners, and is not already public property, as has been the case with previous forest reservations. It is also true that where possible, the work of forest preservation ought to be undertaken by the States. We must take conditions as we find them, however, and the Southern States, it must be admitted, are in no condition financially to do this work. Such States as New York and Pennsylvania and Michigan and Minnesota are able and ought to provide for the preservation of their timber supply within their borders. New York's good beginning in the Adirondack region is familiar to most of our readers. In the South, however, the matter of the preservation of the timber on the Great Smoky Mountains be left to the States it will go by default. The United States can now step in and purchase great tracts of virgin forest a half million acres, more or less, at a cost estimated at $2 per acre. Such a forest preserve, properly administered, with the ripe timber removed, forest fires prevented and new growth to take the place of the old encouraged, should be a source of large revenue and not of expense to the Government.

An investigation of the forest and mountain region that might be included in the proposed park has been made by a Commission appointed by the Secretary of Agriculture, consisting of Prof. Gifford Pinchot, Mr. F. H. Newell and Prof. J. A. Holmes, of North Carolina. A force of a dozen men from the U. S. Geological Survey has carried on the field work. It is to be hoped that their report, which has recently been presented, but not yet made public, may have the prompt and favorable attention of Congress.

THE NEW CLASSIFICATION IN THE U. S. PATENT OFFICE.

The American patent system is generally admitted by competent judges to be, all things considered, the best in the world. The distinctive feature of the American patent system, in which it differs from that of all other principal commercial nations except Germany, is that patents are only granted after a search by the office to determine whether the invention for which a patent is asked is actually novel. Those who have criticised the American system have generally done so on the ground that the field of search is so great that the examiners' approval of an invention as novel gives no guarantee of such novelty. They have argued that it was better to make no search at all than one which must necessarily be more or less imperfect.

At first sight, when one reflects that some 700,000 U. S. patents and 1,200,000 foreign patents have been issued up to the present time, it seems indeed practically impossible to determine with reasonable certainty the novelty of an invention. But when one reflects that this mass of patents covers the whole range of modern arts and industries, it is at once evident that by a proper classification, which shall bring all the patents in each particular industry together, and then subdivide them into still smaller groups according to their specific uses, the examination to test the question of novelty can be made quickly and certainly.

The work of classification in the Patent Office has been a sort of evolution, and has until recently been conducted on somewhat hap-hazard lines. A few years' ago, however, as a result of repeated appeals from successive Commissioners, Congress established a special classification division, whose task it has been to establish the classification upon a thoroughly scientific and practical basis. This work has been so far completed that the new classification is now taking the place of the old in the office work, and a circular describing the plan of the new classification has recently been issued by the Commissioner.

We have before this, in these columns, called attention to the Patent Office Classification and its very great importance and value to all inventors, engineers, manufacturers or others who have aught to do with matters of invention. The adoption of the new classification makes new reference to this subject timely.

The most important respect in which the new classification system is superior to the old is in its system of cross-references. Under the old system suppose an inventor applied for a patent on a rocking grate-bar, it was easy to look through the patents in the sub-class of "grate-bars—rocking," and see whether the invention was anticipated; but such a search would not disclose the possible fact that in some patent, relating chiefly to a boiler, or a furnace, or a traction engine, or

FIG. 1. FOUNDATION FOR ASPHALT PAVING CONSISTING OF THE OLD BOSTON BLOCK PAVING LOWERED AND JOINTS FILLED WITH SMALL BROKEN STONE.

FIG. 2. OLD SPANISH CITY SEWER INLET.

FIG. 3. OLD FORM OF REFUSE-CART.

FIG. 4. CUBAN COUNTRY WAGON, USED IN CITY.

FIG. 5. SMALL PUSH-CART USED BY STREET-SWEEPERS UNDER AMERICAN CONTROL.

FIG. 6. REFUSE-CART NOW USED; CAPACITY, 60 CU. FT.

VIEWS IN HAVANA, CUBA, SHOWING OLD A

William Ludlow, Brigadier General U. S. A., Military Governor of Havana.

FIG. 7. VAPOR STREET—AS IT WAS; JAN. 13, 1900.

FIG. 8. VAPOR STREET, REPAIRED; JUNE 23, 1900.

FIG. 9. OLD SPANISH LAUNDRY IN HAVANA CARCEL.

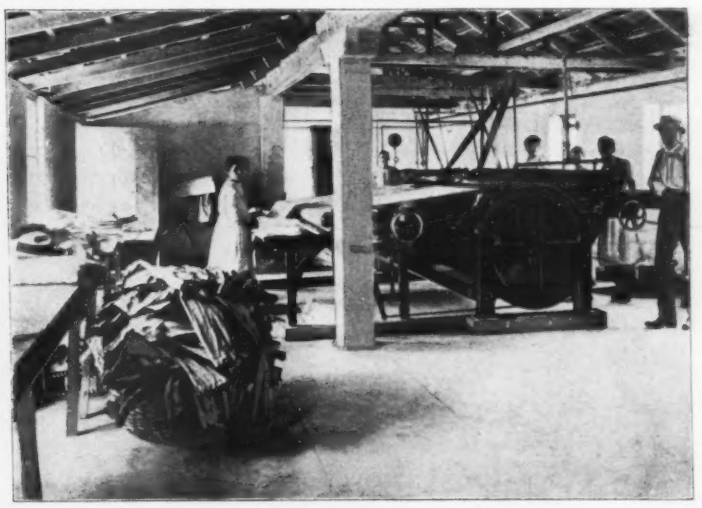


FIG. 10. NEW LAUNDRY METHODS.

FIG. 11. OLD SPANISH KITCHEN IN HAVANA CARCEL.

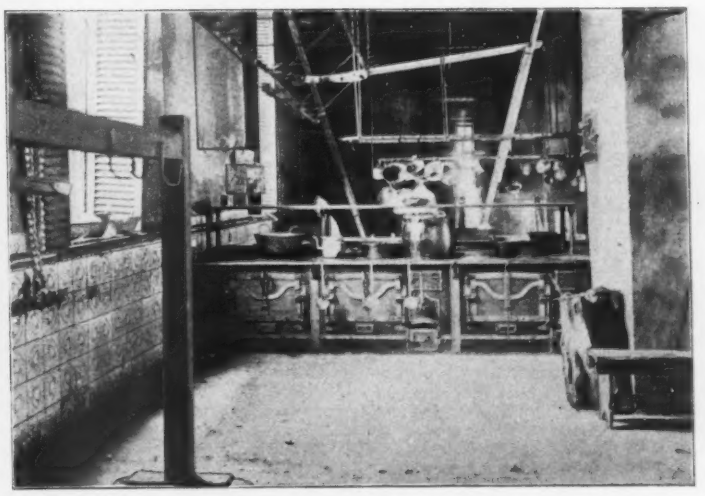


FIG. 12. NEW AMERICAN KITCHEN.

OWING OLD AND NEW METHODS OF SANITATION.

W. M. Black, Major U. S A., Chief Engineer, Department of Havana.

...t not, and so classified elsewhere, this par...lar form of grate-bar might be shown and de...bed and the patent application in question thus ...anticipated. Of course, in the work of the office, ...examiners became so familiar with the art in ...ich they worked that they could frequently find ...h anticipatory patents, even though in another ...-class than that in which the first search was ...de. The inventor or attorney, however, had not ...s familiarity, and this was one main reason ...y many inventors and attorneys have preferred ...file applications without making any prelimi...y search, and let the office settle the question ...novelty.

Under the old regime, the examiners in each di...sion made their own classification, according to ...eir own ideas. This was, of course, fatal to any ...iformity of practice, and when inventions were ...esented which lapped over divisions or classes, ...their location was a hap-hazard matter. In the ...w classification, each patent which contains ...atter coming under two or more sub-classes is ...represented in each by cross-references. Thus, not ...nly the examiner, but attorneys or others having ...access to the classified files of patents in the office ...an make searches to determine the novelty of an ...invention, and can have confidence in the reliabil...ity of such a search. In this feature, indeed, the great public value and importance of the new classification lies, quite as much as in the greater facility and certainty which it will afford to the official examination.

Now that a preliminary search to test the novelty of an invention can be made with such ease and certainty, it will be by all odds desirable to make it in the first place before applying for a patent. With the knowledge thus gained of all that prior inventors have done in a particular field, the inventor may find that his own idea has been so completely anticipated that no patent sufficiently broad to be of value can be obtained. On the other hand, if the search shows that his idea is really novel he will frequently obtain valuable hints as to how to perfect his improvement, and his attorney will be able to prepare specifications and claims in such a manner as to avoid interference with prior patents. The case can thus be passed through the office without the frequent amendments and reamendments which now mark the usual course of an application.

Another feature of value in the new classification system is that patents hereafter issued should have greater assurance of validity. It has long been a saying that a patent is never valid until it has been passed upon by the courts, and one reason for this has been the necessary imperfections of the official search. Under the new system, not only will it be safer in business as in law to accept the issuance of a patent as prima facie evidence of its validity; but investigations to verify the official search and to afford information as to the state of an art at a particular time can be more readily and certainly made.

Of course it will be understood that all these matters have to do only with the question of novelty. With the practical merits or demerits of an invention, the patent office has nothing to do. In future, as in the past, also, the breadth of patents, as defined by their claims, will vary between widest limits. To a large proportion of the public, and even to many inventors and manufacturers, a patent is a patent. It is not understood that a patent is like a deed to a piece of real estate, and that the field to which it grants a title, as defined in its claims, may be anything from a square inch to a square mile, and may vary in quality and value from a desert to a garden. What the new classification will make possible is such an accurate defining of the metes and bounds of the fields belonging to different inventors that overlapping and consequent litigation will be much less frequent.

In order to give this new classification its full public value, however, steps should at once be taken to make it more readily accessible to the public. Up to the present time, the only place where the classified files of patents have been accessible is at Washington. We urged years ago that classified sets should be placed by the Government in public libraries in the larger cities, or at least in such centers as New York and Chicago. The completion of the new classification, with the greater facilities which it offers for preliminary searches, as explained above, makes such action really imperative. The cost of such a distribution, when once the classification is completed at Washington, would be a mere trifle compared with the resulting public benefit. Even were private enterprise to undertake the work, the cost would not be great. The price set by the office for printed copies of patents is 3 cts. each for all those in a sub-class, 2 cts. each when all those in a class are ordered, and 1 ct. each for the entire series. Thus for a public library in any large city to procure the entire set of patents would cost less than $7,000. No similar amount invested in any way whatever by a public library in a large city could afford anything like as great a public benefit.

Another feature worth mention is the advantage to technical societies which maintain reference libraries for the benefit of their members of procuring sets of the patents in the classes relating to their particular specialties. The American Society of Civil Engineers, for example, could enrich its library in no possible way so much as by procuring all the classified patents relating to railways, water supply, sewerage, bridges, and such subjects coming particularly in the field of its members' work. Similarly, the Mechanical Engineers ought to have files of all patents relating to steam engineering and metal working, at least, upon their shelves.

Such work by individual societies would be worth while, even if the Government should undertake some such distribution of classified sets as we have suggested above; its scope, however, would manifestly be vastly less in benefit.

So evident is the duty and opportunity of the Government in this matter that it is greatly to be hoped official inertia and red tape may be overcome and prompt action taken. The Patent Office has these files of old patents lying idle all about its cramped quarters, encumbering space badly needed for the working force, and daily inviting danger from fire and the destruction of records of the utmost value. To make up fifty or even a hundred complete classified sets and distribute them to public libraries in all parts of the country would be a boon to inventors, manufacturers and engineers whose importance it would be difficult to overestimate. All the necessary cost could be covered, and more than covered, by stopping the publication of that now useless anachronism, the "Official Gazette," so that the real cost to the country need be nothing whatever. Indeed, the saving in labor of the official force of examiners in the office through the better and more intelligent preparation of cases which this distribution of patents would make possible, would alone compensate the Government for the entire expense incurred.

LETTERS TO THE EDITOR.

Co-operation Between Engineering Societies.

Sir: I have read the editorial in your issue of Jan. 17, referring to the co-operation of the two engineering societies, civil and mechanical, and wish to send a word of hearty approval. I think such a combination is desirable from financial as well as other standpoints; and I trust that Engineering News will pursue the subject to a successful end.

It appears to me that the annual dues should be reduced so soon as the indexing of the library is completed, if not earlier. I am sure there are many members who would be very glad to see such a reduction made. Very truly,

Wm. M. Hall, M. Am. Soc. C. E.

Cincinnati, O., Jan. 22, 1901.

Credit for Designing the Sanitary Sewerage System of Charleston, S. C.

Sir: In your issue of Jan. 10, under the caption "Municipal Improvements at Charleston, S. C.," I note that Mr. S. M. Gray, M. Am. Soc. C. E., is credited with the design of the sanitary sewerage system, which is intended eventually to cover the entire city. This is an error. The system, including plans and details for sewage and garbage disposal, was designed by me in every feature. The portion constructed was built under my personal supervision. After the plans were prepared, Mr. Gray was engaged by the sewer commission to examine and report on them, since they involved several novel features. Mr. Gray fully approved and the plans were adopted without change of a detail. Respectfully yours,

Baton Rouge, La., Jan. 27, 1901. R. Frank Hartford.

Appearance of Water from the Albany Purification Works During the Freshet of February, 1900.

Sir: In your issue of Jan. 10, in the letter from Charles R. Parmelee, Consulting Expert for the New York Continental Jewel Filtration Co., replying to a letter from Mr. F. A. W. Davis, Vice-President of the Indianapolis Water Co., Mr. Parmelee says: "That the plant of the city of Albany during the freshet of last spring delivered an effluent which in appearance was anything but satisfactory."

I have had charge of the Albany city water works for nine years, and when things are not satisfactory complaint is made to me. The complaint of Mr. Parmelee is the first that I have ever heard that the water delivered during the time of the freshet of Feb. 14 and following was unsatisfactory.

Our records show that the greatest turbidity of the filtered water, as measured on the platinum wire scale, was for one day 0.025, which is equivalent to seeing an ordinary dull pin through 40 ins. of water. The greatest turbidity of the raw water during the freshet was 0.900, equivalent to seeing the same pin in 1.1 ins. of water.

The "unsatisfactory" feeling or expression must have come from some exquisite. Yours truly,

Geo. I. Bailey,
Superintendent Bureau of Water.

Albany, N. Y., Jan. 30, 1901.

The True Cause of the Complaints Made of Our Engineering Schools.

Sir: I graduated in 1886 from a well-known engineering college and after five years' experience on railway location and construction found myself "out of a job." The president of my "alma mater" offered me the position of assistant instructor in civil engineering, my duties to consist in instructing in field work and railway engineering. The salary offered was $900 per year and that being better than nothing, the offer was accepted and I "instructed" to the best of my ability for the remaining two terms of that year. My services were probably satisfactory, for I was asked to serve another year. I replied that I would, but it must be at a salary of at least $2,000 per year. "Impossible," said the president. "Why that is more than we pay many of our professors. I can get plenty of good men for less." I answered that a railway company had offered me that salary and that if such a soulless corporation, as a railway is generally considered, thought me worth that sum, he would certainly not consider a cheaper and naturally a poorer man capable of teaching young men the principles of railway engineering. It goes without saying that the college let the railway have me, and here, I think, will be found the true cause of many of the complaints made of our engineering schools. The chief or head of our engineering schools is nearly always a well-known engineer and one of wide experience, but he continues outside practice after accepting the college position, and delegates nearly all of the real teaching to the instructors. In most cases these instructors are recent graduates from the same school with little or no experience in the practical work of the profession. Let the colleges pay their instructors salaries equal to those paid by railway, water and mining companies to their principal engineers, and, I think, the young man will leave college with a better combination of theory and practice than he does now. '86.

Kiachta, Siberia, Russia, Dec. 10, 1900.

Royalties for Using the Septic Tank and Double Filtration Demanded of Plainfield, N. J.

Sir: Persistent attempts are being made by Mr. J. N. McClintock, President of the American Sewage Disposal Co., of Boston, Mass., to make engineers and communities contemplating the use of septic tanks believe that the Glover patents of 1882 and 1896 "cover the process of septic action and filtration"; the latest attempt being a communication to the authorities of Plainfield, N. J., in which a 10% royalty is claimed.

Engineers who are familiar with the subject, and have examined the Glover patents, are not likely to be disturbed by Mr. McClintock's statement; as there is nothing in the patents which supports his claims or would lead any one to believe that Mr. Glover had any conception of the septic tank principle. The ordinary reader of Mr. McClintock's communications to the public press does not, however, know the facts, and is likely to be misled, by the boldness of the language used, into the belief that it is necessary to pay a royalty or go back to older methods of sewage disposal.

In the case of Plainfield, the matter has been referred to the corporation counsel and will receive proper attention, but in other places, useful public improvements may be

postponed unless the subject is well ventilated in the public press.

Mr. McClintock claims in regard to the proposed Plainfield works, which were recently designed by me, that they infringe on the Glover patents, although not a single item of similar design or principle is set forth in Mr. Glover's claims. On the same principle he can claim a royalty on almost any modern sewage disposal plant of whatever nature.

It does not appear, although a considerable number of septic tanks have been constructed in this country, that any suits have been brought by Mr. McClintock, and I do not learn that any one has yet paid him a royalty. I trust that we may hear from others on this subject.

Yours truly, Jos. O. Osgood, M. Am. Soc. C. E.

71 Broadway, New York city, Jan. 28, 1901.

(Our own views on the relation of the Glover patents (No. 258,744, dated May 30, 1882, and No. 559,522, granted May 5, 1896), were stated in our issue of Dec. 7, 1899, in a reply to a letter from Mr. McClintock urging that the recent U. S. patents to Mr. Donald Cameron and associates, of Exeter, England (No. 634,423, Oct. 3, 1899), conflicted with the Glover patents. We then said:

The Glover patents neither describe nor claim any of the special features included in the septic tank patent. In fact, the two systems of sewage treatment are apparently at variance in that the American proposes to ventilate the tanks through a central shaft, whereas the Englishmen exclude the air from their tank as fully as possible. Notwithstanding this divergence in descriptions and claims, it seems probable that tanks constructed in accordance with the description in the first Glover patent might be so operated as to bring about a large amount of anaerobic action; but might not the same be true of any other sewage tanks constructed on the continuous flow principle?

We fear this question may not bring any great degree of comfort to the Plainfield authorities, since it raises the question of the bearing of the Cameron patents on the use of the septic tank in the United States.

Since the foregoing was written we have received a communication from Mr. McClintock, relating to the old Mouras patents, taken out in France some twenty years ago, and claiming that Mr. Glover's invention antedates that of the Frenchmen. The Glover patent of 1882, whatever its merit, has, of course, expired.—Ed.)

The Mouras French Patents, the Glover Patents and the Septic Tank.

Sir: Referring to the discussion of the paper read by myself Aug. 29, 1900, before the American Society of Municipal Improvement, reported in the proceedings of the society lately issued, p. 102, I find the following statement by Mr. M. N. Baker, of the editorial staff of your journal:

It may be interesting to put on record alongside with that statement (that Mr. Glover invented the septic tank) the fact that has been brought out by nearly all of the technical papers on this side of the water that way back in the '70s there was described in a French paper . . . a system which in general was virtually the septic tank, or, as someone has called it "The glorified cesspool."

That was in the early '70s, if I remember correctly, where some Frenchmen described in a French journal a system of sewage disposal by means of a modified cesspool.

The article referred to was published in a series of three parts in the December, 1881, January, 1882, and the January, 1883, numbers of "Cosmos les Mondes," and was written by the editor, Abbe F. Moigno, in the interests of the inventor, M. Mouras.

An examination of the French patent office files shows that M. Mouras was granted "Brevet No. 144,904," Sept. 22, 1881, with "Certificat d'adition," Feb. 28, 1882, on a "Vidangeuse Automatique."

The patent was for a cesspool, fully described in the patent, and applied septic action to the cesspool. M. Mouras's discovery of septic action dates from the time he applied for his patent, Sept. 22, 1881. He never took out a patent in the United States.

Mr. Amasa S. Glover applied septic action to the sewage disposal of a city and demanded a patent Oct. 15, 1881, and was granted Patent No. 258,744, May 30, 1882.

It is a matter of record that he had his model on exhibition Sept. 7, 1881. It is also a matter of record that his discovery was derided and scorned by boards of health for many years. Sept. 23, 1895, Mr. Glover applied for a patent on septic action (then denied by official authority as existing) combined with filtration for sewage disposal for a city, and was granted May 5, 1896, Patent No. 559,522.

Mr. Glover built at Brentwood, N. H., in the fall of 1895, disposal works still in operation, combining septic action with filtration and obtaining the required purification of the effluent to satisfy the health authorities—the first built anywhere in the world.

Mr. Cameron followed M. Mouras's ideas of making his septic tank air tight, whereas Mr. Glover was in line with the latest and best practice in lighting and ventilating his tanks.

It is a matter of common knowledge, in Brockton, Mass., where Mr. Glover lived, that he claimed that his tank would liquefy and disintegrate all organic matter submitted to it. He gave out at the time that it eat up a pair of leather boots, and there are hundreds of living witnesses who saw his experimental plant at the Brockton Poor Farm in operation in 1881 or 1882. As to his Brentwood plant being in operation in 1895, I refer you to the report of the U. S. Geological Survey, 1899, No. 22, p. 42 ("Water Supply and Irrigation Papers," No. 22, "Sewage Irrigation," Part II., by Geo. W. Rafter, M. Am. Soc. C. E., who speaks of the tank as a "collecting tank . . . . where most of the sludge is deposited."—Ed.) and the "Engineering Record," May 9, 1896.

Having built the Brentwood plant, Mr. Glover died in 1897 at the age of 80; his company went to pieces; the patents were sold and our company came into possession and together with his heirs propose to establish his fame and our rights. Yours truly, John N. McClintock,

Pres. & Mgr. American Sewage Disposal Co.

89 State St., Boston, Mass., Jan. 28, 1901.

Mathematics in Engineering Schools.

Sir: If you are not tired of letters on the subject of "Mathematics in Engineering Schools" I should like to make one suggestion which seems to have been overlooked. We are told by some correspondents that the difficulty is with the teachers and by others that the text books are faulty. Some have even attempted to explain in detail wherein the instruction is defective. Through it all it has been tacitly assumed that there is something radically wrong with the mathematical teaching in the technical schools. I wish to enter a flat contradiction of this gratuitous assumption I am personally familiar with several engineering schools and know that in them the mathematical instruction is excellent in every particular. The text books are good. The teachers are experienced and able. They do not teach a mere jumble of formulae without illustrating principles by the solution of problems. On the contrary, they solve numerous problems in the class rooms and require the students to solve many more at their homes. There is every reason to believe that the instruction is equally good in other schools of this kind. (By way of anticipating a possible criticism from some of your readers who may think that this is a personal matter and that I am merely defending my own practice, I will say that I am not a teacher of mathematics.)

But some one will say "If the instruction is so good how do you account for the fact that many engineering graduates have their heads so full of mathematical formulae that everything else is crowded out, while they do not even know the meanings of the formulae?" The answer is easy. The fault is with the student. Some young man dazzled by the success of a friend or acquaintance who has pursued an engineering course straightway concludes that this course is the key to success and enters an engineering school. He is a failure and people busy themselves inventing explanations of the fact and blaming everyone but the young man in question. At present the mathematical department is the scapegoat. The fact is that our technical schools are full of men who have no more business there than had the traditional bull in a china shop. The public, strange to say, seems to think that while special aptitude is required in order that a man shall be a successful lawyer, physician or preacher, any one may become an engineer, and the engineering school is promptly condemned because it does not make a silk purse out of every one of the innumerable sows' ears which make up the bulk of its raw materials. Some of our engineering students might be excellent lawyers. A few would make very good physicians. A large number would become with some training fair carpenters, blacksmiths or ribbon salesmen. A small percentage will really be engineers and some among them will be the great engineers of forty years hence. "But," I think I hear some one say, "why do you graduate these men who are not fit for the profession?" Probably every engineering faculty in the country has graduated men whom the instructors felt would never be engineers. However, these men had fulfilled the requirements for graduation. By industry and the use of good memories they had been able to perform the tasks set for them sufficiently well so that they must be allowed to go on from year to year and finally graduated. A man is graduated on his record and his record depends upon the visible results of his work in the class room and laboratory—not upon the instructors' convictions as to his future. I am not aware that any engineering school in America pretends to make engineers. What it pretends to do and does is to furnish a sound basis on which to build the experience which may make the finished engineer. To blame the engineering school because everything that passes through its sieve does not become an engineer is as sensible as to blame the university because every graduate of its academic course does not become a poet, a novelist or a historian.

It is not worth while to adduce arguments as to whether or no the so-called "higher mathematics" should be taught in engineering schools. I believe with Prof. Ricketts that "the time has gone by when it is necessary" to argue this matter.

In your issue of Nov. 8, 1900, Mr. E. Sherman Gould compares the engineering schools with the Military Academy, the Naval Academy and the medical schools to the disadvantage of the former. He asks why West Point, Annapolis and the medical schools accomplish their respective purposes so much better than the engineering schools. I ask "Do they?" There is authority back of the institutions mentioned. The government says that a graduate of West Point or of Annapolis is competent to do certain things and emphasizes this statement by giving him a command—of such a character, however, that his blunders cannot do any great damage. The law says that a graduate of a medical school is competent to practice medicine, and practice he does. "The law" is to most people a kind of god, so if "the law" says that John Doe is a physician he must be one. "The law," however, does not say that Richard Roe is an engineer, so Richard Roe may or may not be an engineer. The people concerned must take steps to find out for themselves. In reply to Mr. Gould's question I will say, like the man unable to explain the creeping of the rails over the Eads bridge, "I doubt the facts." Yours truly,

Charles W. Comstock.

School of Mines, Golden, Colo., January 16, 1901.

Stream Pollution by Alum in the Wash Water from Mechanical Filters.

Sir: I have looked over the criticisms by the New York Continental Jewell Filtration Co. of my suggestion in regard to stream pollution from wash water from mechanical filters, published in your issue of Jan. 10. The Filter Co. says:

Hydrate of alumina, or an equivalent coagulant, is required for the successful filtration of many surface waters, in order to aggregate those fine clay particles that pass through a filtering medium, which was sufficiently high in quantitative efficiency to be available from an economic standpoint for the purification of municipal supplies. This is undoubtedly known to Mr. Davis.

Mr. Davis knows of the claims of the Filter Co., but he believes that with proper sedimentation water can be better purified by sand filtration than by mechanical filters, which require the use of a coagulant.

While the Ohio River is able to carry off a large quantity of wash water, there are small streams that cannot. To take 1.75 grains to the gallon of sulphate of alumina and assume that it is infinitesimal, when the river is high, is not fair. When the river is high 15 grains are required and the effluent is not satisfactory.

The Filter Co. says:

With reference to the relative desirability of utilizing some method of purification which does not require a coagulant, we do not desire to take exception to the attitude held by Mr. Davis, but we beg to call the gentleman's attention to the fact that Louisville, Cincinnati and Washington have spent large sums of money, thus far unsuccessfully, in the endeavor to find methods of purification which would avoid the use of coagulant; that the city of Pittsburg in proceeding with the designs of English filters does so in the face of clear evidence that at times the plant will not be able to deliver a clear water; and that the plant of the city of Albany during the freshet of last spring delivered an effluent which in appearance was anything but satisfactory.

I do not question the statement that large sums were spent at Louisville, Cincinnati and Washington. How necessarily, I cannot tell, but this I do know: It was demonstrated that the effluent was not satisfactory at all times, notwithstanding as high as 15 grains to the gallon were used; that some of the alumina did get into the effluent; and that the sulphate of alumina did increase the hardness, corroding and incrusting qualities of the water. That portion which combines with the lime and magnesia, forming the white flocculent hydrate of alumina, resting on the top of the filters and is washed into the stream, must in my opinion be stream pollution and that which goes into the effluent does not change the condition of the water for the better.

The Filter Co. says that the plant at Albany did not give a clear effluent during the spring freshet. (See letter from Mr. Bailey in this issue.—Ed.) Possibly it did not, but the showing with the mechanical filters (elsewhere in time of freshet?—Ed.) was no better with greatly increased cost of alum. If there is to be any criticism of the Albany plant it is that the subsidence basin is not large enough.

Taking a water-works plant pumping 25,000,000 gallons a day and using 1.75 grains of sulphate of alumina per gallon, which is equal to 6,250 lbs. a day, this converted into a flocculent hydrate of alumina and washed into the river every day must unfit the water in the river for other water-works plants and other uses and if it does it must be pollution. It does not matter if the stream be large, it is wrong in principle. If we have a right to pollute one stream, why not all streams?

The Norfolk filter plant used 378,000 lbs. of sulphate of alumina in seven months. This went either into the river or the effluent. Surely the wash water from the filters did not increase the purity of the river, neither was the effluent bettered only to a certain degree, for is it not less fitted for some uses than it was before it was changed by the sulphate of alumina? In sand filtration, the water is improved without changing its composition.

I do not know that Louisville spent a large sum for experimental work. I always understood it was the filter companies. The experiments of the other cities were at

the public expense. The filters erected and tried at New Orleans were a failure and a large loss to the Filter Co. The experiments at Louisville and Cincinnati clearly demonstrated that to be successful with mechanical filters, there must be large subsidence basins constructed and the cost of these must in future be estimated when mechanical filters are under consideration.

The sulphate of alumina increases the corroding and incrusting qualities of the water. This being the case, to what extent is the water purified or bettered by the use of a coagulant? Must not the answer be that to the extent the corroding and incrusting qualities are increased, the water is deteriorated? This deterioration must be deducted from the clarifying and bacterial results to get at the true value of the mechanical filtration.

Pittsburg, being a manufacturing city, it seems to me, has decided wisely on sand filtration because of the increased acidity of the water, when mechanical filters are used with sulphate of alumina as a coagulant, which makes the water somewhat objectionable for manufacturing purposes.

In conclusion, I quote from the Filter Co.'s statement as follows:

Hydrate of alumina, which is the product resulting from the decomposition of sulphate of alumina by lime, and which is the active coagulating agent, is, however, present in the wash water. This is the compound which holds the suspended matter together and which is removed, together with the suspended matter, by the process of purification, consisting of subsidence and filtration, which is known as the American system. In cleaning the settling basins and filters, these materials, in the form of a thick sludge, are removed and pass normally into the sewerage system and thence either to the sewage purification works or to some running stream.

This clearly states what is thrown into the stream, and it is this flocculent, whitish, insoluble substance, or sludge, which is thrown into the stream that I believe is stream pollution. That there are others polluting the stream, according to the following opinion of the Supreme Court, makes no difference:

Riparian owners have, also, a natural right to have a natural stream flow unimpaired in quality as well as quantity; and any use of the stream by one proprietor, which defiles or corrupts it to such a degree as essentially to impair its purity and usefulness for any of the purposes to which running water is usually applied, is an invasion of private rights, for which those injured thereby are entitled to a remedy.

F. A. W. Davis, Vice-Pres. Indianapolis Water Co.
Indianapolis, Ind., Feb. 2, 1901.

The Bacterial Treatment of London Crude Sewage.

Sir: I have examined the "third report" of Professor Clowes, of London, upon bacterial treatment of crude sewage, and have read with interest and approval your comments upon it in Engineering News for Jan. 24, 1901. When I visited the works in London, last May, it seemed to me that the experiments were hardly on a sufficient scale for the work which was being done by Dr. Clowes and Dr. Houston, and I found at Leeds what appeared to me to be a more adequate system of experiments, so far as the mechanical means were concerned. On the other hand, the Clowes report is the most thorough I have yet seen, and the report is a marvelously good example of the benefits of having thoroughly competent men in the chemical and biological departments.

It is to be kept in mind that the purpose in London is severely practical. Into the heavy tidal flow below the city the sewage is now dumped, after chemical precipitation. The sludge is carried to sea by six steamers at great cost. If there is a way to get as pure an effluent with an equal or smaller quantity of sludge, and for less money, London wants it. And Dr. Clowes has answered affirmatively the question whether by straining, settling and filtering through coke-beds London will get equal or better results at smaller cost. In short, the bacterial processes indicated have been demonstrated to be equal or superior to chemical precipitation, and cheaper.

Incidentally, we find that if the experiments have shown excellent results in the reduction of the noxious qualities of sewage, the margin of danger after a treatment which may be regarded as fairly thorough is so great as to warrant its substantial rejection by Dr. Clowes, in any case where the effluent could reach a water supply.

I confess discouragement from this "third report," from the other recent literature, and from my own observations abroad, as to any means of treating the sewage discharge of cities by which the effluent would be allowed to reach the sources of water supply for domestic purposes. We are occasionally told by our water engineers that the problem of maintaining a pure water supply belongs to the authority in charge of sewerage; that means to prevent the pollution of the rivers used for supplies must be relied on to save the public from the disease and death consequent upon using polluted water. That is true enough in a measure, but the sources of supply should in any case be far removed from centers of population, and the attempt made to convince the public that water can be maintained in natural purity when there is a sewage effluent entering its sources at any point should be discouraged. In other words, the burden is upon the water engineer, as upon the laborer in this misty subject of sewage purification.

May I call attention to the first note under "general conclusions" in the report of Dr. Clowes?

It is assumed that no contamination of the underground water in the Thames Valley takes place as a result of the pollution in the lower reaches of the river affecting distant sources of water supply (e. g. deep wells). If in the future reliable evidence to the contrary should be forthcoming, then the whole question might require reconsideration.

Does the note indicate a doubt?

I need not say that the report of Dr. Clowes has an important bearing upon the problem which now confronts the New Jersey State Sewerage Commission, the Passaic River pollution, and that light is gained by the facts stated and conclusions reached. Very respectfully,

William T. Hunt,
Chairman State Sewerage Commission of New Jersey.
Newark, N. J., Jan. 29, 1901.

The Competency of Correspondence School Graduates.

Sir: I recently had occasion to advertise for strong, able-bodied men, having had mathematics through trigonometry, to put in their application for positions in a field engineering corps, which is now working under my direction. Up to this date I have received several applications from those holding diplomas from certain correspondence schools. This not satisfying me as to their qualifications, entirely, I addressed some questions to one of the applicants who had written me when making his application, as follows:

I have completed the preparatory and intermediate division of the complete mechanical, electrical and engineering course, which includes, among other subjects, trigonometry, geometry, elementary mechanics and hydromechanics.

The questions addressed him were:

Will you please state when you began your study with the ——— school, how many hours you devoted to your work on an average, how long were you pursuing the study of geometry, how long the study of trigonometry, how long elementary mechanics and how long hydromechanics? Please answer these questions quite definitely and return with your application.

To this letter I received the following reply:

——————— Jan. 16, 1901.

Dear Sir: You will find below the time (as near as I can reckon) it took me to complete each subject. As I did not pay particular attention to the time I took I cannot give you a very satisfactory answer to your questions. I began my study with the ——— school one year ago last 12th September. For trigonometry and geometry (which are included in one instruction paper) it took me on an average of about two hours a day for about twenty days. For elementary mechanics it took me on an average of about two hours a day for twenty-four days. For hydromechanics, two hours a day, for about twenty-five days. Yours truly, ———————.

The writer also had an application in person, from a young man of his acquaintance, who is at present taking a course with this same school. He informs me that he began his study at the very lowest branch, viz.: Addition, subtraction and continued right on up through the various mathematical branches, and has now reached trigonometry. When the question was put to him as to when he began his study, I was astonished when he made the reply that he began his course some time in October last.

Another applicant, who had finished his course in arithmetical drawing, accompanied his application with his diplomas and the drawings he had made, thus giving me an ocular demonstration of the class of handiwork he was able to get out. It pains me to do it, but I must say that the drawings were simply shocking, although the hopefulness of this applicant's letter would indicate that "he thought he knew all about it, and just how to do it," and was prepared to do acceptable work at the draftsman's table.

Now, I am interested to know, after the knowledge which these developments has revealed to my mind, if this is the class of scholarship and training which we are to understand that correspondence schools are supplying? Everything connected with these applications to me only confirms the profound conviction I have had for some time, that perhaps these schools were turning out a mass of incompetents, who are innocently supposing they have been taught all there is to know in the various branches of technical studies they have pursued, and which I am forced to believe will react to the sorrow both of the employer and employé, when such employé has nothing further to commend his abilities than the mere diploma, which the latter has to offer as a guaranty. I have no knowledge of what tuition is charged by these institutions, and wish to be set right if I am forming wrong conclusions in this matter.

I shall be very glad to hear a straightforward opinion from the editorial rooms of your valuable paper.

Yours very respectfully,
Chicago, Ill., Jan. 23, 1901. Chief Engineer.

(The subject of correspondence schools and their work was briefly reviewed in the report of the committee of the Society for the Promotion of Engineering Education on American Industrial Education, published nearly in full in Engineering News of July 12, 1900. This summary of the possibilities and limitations of such schools seems to us to cover the matter so fairly and fully that we quote it in full. As a further introduction it may be stated that the committee of whose report the quotation is a part was composed of the following well-known engineering educators: Prof. J. B. Johnson, Dean of the College of Mechanics and Engineering, University of Wisconsin; C. M. Woodward, Professor of Mathematics and Applied Mechanics, Washington University; Prof. R. H. Thurston, Director Sibley College of Engineering, Cornell University; H. T. Eddy, Professor of Mechanics and Engineering, University of Minnesota; Geo. F. Swain, Professor of Civil Engineering, Massachusetts Institute of Technology, and Edgar Marburg, Professor of Civil Engineering, University of Pennsylvania. The full report, together with several comprehensive papers on correspondence school education, will be found in Proceedings of the Society for the Promotion of Engineering Education for 1900. The part of the committee report relating to correspondence schools is as follows:—Ed.)

Correspondence Technical Schools.—These have sprung up like magic in America in the past ten years and are now thought by many to be serving a great need. Whether they will remain in demand, or are only a passing phase of educational opportunity, may be a question. Until other opportunities of acquiring a technical training become practically universal, however, it is very clear that they will find a great work to do. The fact that a single one of these schools (the oldest one) is now carrying on its roll of students over 200,000 names is the best proof in the world of the great demand for technical education. These schools supply their students with specially prepared texts and have systematic correspondence methods of imparting instruction. If the student is willing to do his part he may obtain in this way a very fair substitute for a school training. He lacks the stimulus, however, of a direct personal contact with a teacher and with other workers in the same subjects. This advantage can be partly supplied by a little encouragement from employers. Some establishments are now supplying rooms, fitted with drawing tables, warmed and lighted, where the correspondence school students, amongst their employees, can spend their evenings in study. Where the numbers are sufficient the correspondence schools may eventually find it to their interest to supply local teachers. This would vigorously supplement the work of the correspondence school where it is now weakest. The entire absence of laboratory and shop instruction in correspondence courses, however, is a serious disadvantage, particularly in technical instruction.

An overwhelming majority of the students who begin these correspondence courses become discouraged, or find themselves overburdened or else have not the requisite application, and so stop work in the early stages of their correspondence courses. This is not surprising when the persistent, systematic and seductive methods of obtaining subscribing students are fully understood. Still the truth remains that if a young man really wishes a technical education and is willing to do his part, he can get a great deal of elementary assistance in this way, be he in the slums of a large city, or on a cattle ranch in Texas, or in the South African gold mines. And these necessities of the isolated learners will probably always make a large demand for correspondence instruction, no matter how general other means of acquiring a technical education may become. These schools are but another evidence of the quick initiative of Americans. The demand was no sooner felt than the supply was forthcoming in this new and original kind of a school. Such schools, however, can never supply the place of any of our regularly organized and equipped day, or even of our evening, technical schools.

Notes and Queries.

In regard to the article on Impact Tests of Iron and Steel at Purdue University, Prof. W. K. Hatt writes us as follows:

Will you please note the following corrections to my communication published in your issue of Jan. 31, p 83: In Fig. 1 the heavy line marked "Resilience in inch pounds per cubic inch" should be "Resilience in foot pounds per cubic inch." In Table 1, column headed "No. of test," should read "Number of tests"; also the four tests on bar No. 2 of the nickle steel should have been marked, in the last column, "Impact Test" instead of "Gradual Test."

(The errors noted above were contained in the original manuscript from which the table and drawing were prepared for publication.—Ed.)

MONIER PIPES AS A PILE COVERING, AND FOR CYLINDER FOUNDATIONS.*

By Ernest Macartney De Burgh, M. Inst. C. E.

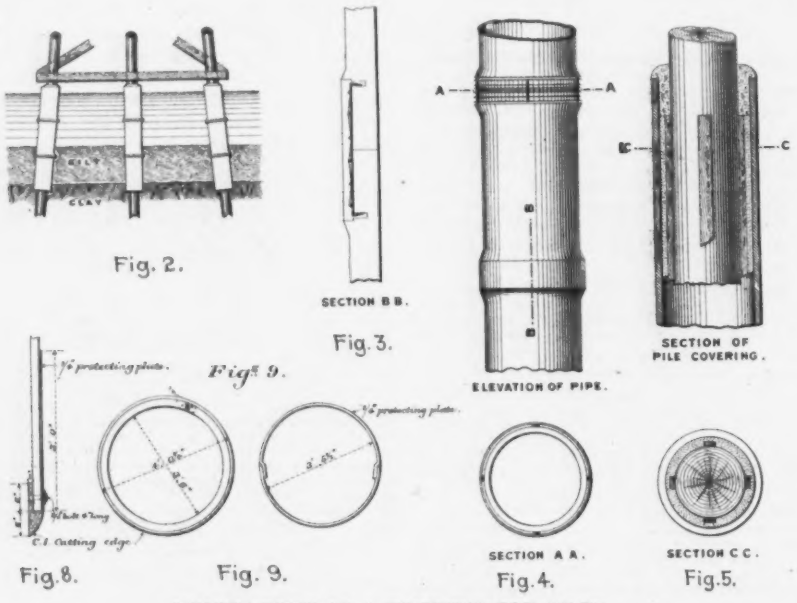
In spite of their great density and durability, the Australian hard woods are not proof against the attacks of the Teredo navalis, or cobra, and in New South Wales and other Australian colonies it has been customary to protect piles, before use in sea water, with a sheathing of copper or Munts metal. Such a sheathing, however, possesses certain disadvantages, namely: it is liable to injury during the process of driving the piles, and such injury cannot be detected if below the surface; it may be destroyed or injured by objects striking and tearing it, while in water carrying sand in suspension it is quickly reduced in thickness, and is ultimately cut through; and it is costly to replace. As an alternative to metal sheathing, pipes have been used, sunk as a covering round the pile,

*From a paper in the Proceedings of the Institution of Civil Engineers.

and subsequently packed with concrete; but ordinary earthenware pipes, while presenting a good hard surface, capable of resisting the Teredo and the action of salt water, are not satisfactory, as frequent faucet and spigot joints are unsightly and impede the sinking of the pipes, while the irregularity of the pipes makes good jointing difficult, and the material does not lend itself to an improved flush joint. Further, the joints have very little strength longitudinally, which makes it difficult to handle a series of pipes. Even if successfully placed the earthenware is readily fractured by any object striking the pile, or by expansion of the concrete inside.

It appeared to the author that pipes constructed on the Monier principle, in which steel netting and wires are introduced into the body of the cement forming the pipe, the bottom. A jet of water from a 1½-in. pipe was then worked round the bottom of the casing to loosen the underlying material, and pressure being applied by means of screw-jacks at the top the casing sank easily to the clay bottom. The space between the casing and the pile, having been scoured out with the jet, was filled with clean sand, finished with 9 ins. of concrete at the top to form a cap, Fig. 5. The casing presents a neat appearance, and the author is satisfied that it will prove of great durability, outlasting the pile, which, being of ironbark, may be counted on for a life of 30 years when protected from the Teredo.

The pipes used were constructed on the usual Monier principle, being 1⅜ ins. in thickness, of cement mortar on a groundwork of steel-wire netting of 1¼-in. mesh and



MONIER PIPES AS A COVERING FOR PILES.

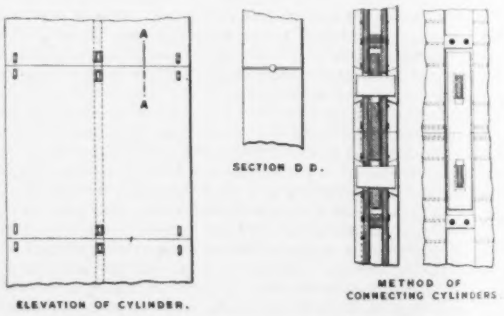
thereby increasing the tensile strength, would be in every way suitable for pile covering, in places where the formation underlying the water admits of their being sunk around the pile to such a depth as to bar the entrance of the Teredo below them. These pipes are exceedingly strong to resist fracture, either from internal pressure or by a blow, and even if cracked they do not fall to pieces; they can also be jointed in such a manner as to have considerable strength longitudinally, which makes them easy to handle, while the joints can be made flush. A most important advantage is that a series of these pipes will withstand the pressure necessary to force them down into the formation, without cracking as earthenware pipes do. It might be suggested that salt water would percolate through the Monier pipes, and would destroy the steel-wire foundation to which they owe their strength; but it has been found by experiment that a column of pipes, 14 ft. in height, has remained for 5 months filled with water without showing any sign of moisture on the outside. The author also considers that, even if the water did reach the wires, there could not be sufficient circulation in the Monier to enable fresh particles of water to come into contact with the wires, to continue the work of oxidation. However, additional precautions were taken to prevent any risk of this occurring, the pipes being freely coated with Stockholm tar, inside and outside, before using, thus effectually choking the pores.

In a traffic bridge over Cockle Creek, near Sydney, New South Wales, five timber piers, having three piles in each, have been protected by Monier pipes. The formation is sand mixed with vegetable matter, overlying stiff clay to a depth of about 5 ft., and it was considered desirable that the piles should be protected down to the point where they enter the clay, in order to provide against the possible removal by scour of the soft upper strata. The piles were of ironbark, about 40 ft. long, 14 ins. in diameter at one end, and 18 ins. in diameter at the other end, driven 15 ft. into the clay. From the level of the clay to high-water level four hard wood battens were spiked to act as guides for the pipes (Fig. 5), and the piles received a coating of Stockholm tar before being driven. Driving having been completed, a small platform was attached to the pile above high-water level, and upon this was erected, by threading over the head of the pile, a sufficient length of Monier pipes, 21 ins. in diameter, to reach from high-water level to the clay bed. The pipes were then jointed with a wire-netting cover and cement, Figs 3 and 4. While the joints were setting, the capwales were fixed to the piles to bring them into position, and to avoid movement after the pipes were sunk. The platform was then removed, and the pipe casing was lowered by means of hooks under the bottom length of pipe until it rested on No. 16 gage wire. The cost of the casing depends almost entirely upon the facilities for carrying the pipes, and if a large quantity were used they might with advantage be made on the work. The author estimates the cost per linear foot in New South Wales roughly at between 50% and 100% greater than that of coppering, and he considers that the effectiveness more than counterbalances the additional outlay in situations suitable for its use, such as that described.

MONIER CYLINDERS IN FOUNDATIONS.—Cast-iron cylinders are largely used in New South Wales for bridge foundations in salt water, but a great advance in the price of pig-iron directed the attention of the author to the necessity for finding an economical substitute. The experience gained in the use of Monier pipes as a pile covering pointed to its adoption for cylinders. The chief difficulty anticipated was that of making a strong longitudinal connection between the various lengths of cylinder required to make up each pier. The cylinder finally adopted was 2⅛ ins. thick, in lengths of 3 ft. 7 ins., with an internal diameter of 3 ft. 6 ins. and was made up of one layer of steel-wire netting (1¼-in. mesh and 16 gage wire) and two spirals of No. 8 gage steel wire wound completely round the cylinder, the turns being 1 in. apart. The longitudinal connection was formed by six steel bars 1¾ ins. by ¼-in., placed between the wire spirals. These bars are so arranged that those of adjoining cylinder lengths can be coupled together by means of a small fish-plate and steel wedges, Figs. 6 and 7.

In sinking the cylinders, the joints were made with red lead to prevent leakage, and it was found that when several segments were joined together they could be lifted without disturbing the joint. A cast-iron cutting segment was used to protect the bottom edge of the cylinder, and, as a protection against damage by the men's picks, a thin steel-plate guard was provided for the inside of the cylinder, up to a height of 4 ft., but in practice this was not found necessary (Figs. 8 and 9). The cylinders were sunk through gravel, sand and clay, to a depth of 36 ft. below the surface of the water, and as it was found possible to keep them pumped dry if well pressed down by means of screw-jacks, the air-lock was not required. When a satisfactory foundation was reached, the cylinders were filled with concrete in the usual way, the inside surface of the Monier being carefully cleaned to get as good a bond as possible with the concrete. Had an air-lock been required no difficulty was anticipated in attaching it, as the cylinders were quite as true as if cast, and a suitable flange could be readily bolted on to receive the air-lock.

The cost of these Monier cylinders delivered at the site was 24s. ($5.75) per ft. run, while that for cast-iron cylinders of the same diameter would have been £3 ($14.65) per ft. run. These prices, being local and governed by the ruling rate for cement and cast-iron, can only be taken as an indication of comparative value. The author, however, is satisfied that, especially when cylinders of large diameter are used and such quantities are required as justify the erection of a plant to make them on the site of the works, a large saving may be effected by their use, and he considers them eminently suitable for such foundations in soft material.



THE EXPORT OF MANUFACTURES OF IRON AND steel in 1900, amounted in value to $129,633,480, says the U. S. Bureau of Statistics. This value is exclusive of iron ore. In comparison, the similar export in 1899 amounted to a little more than $27,000,000; it was only $62,737,250 in 1897. The 1900 exports, in round numbers, amounted in value to: Pig iron, 4,500,000; builders' hardware showed a gain of over 1,000,000 over 1899 and 2,000,000 over 1898. Steel rail exports for 1900 amounted to nearly $11,000,000; electrical machinery exported was worth $2,250,000; sewing machines, $4,500,000; and typewriters near $3,000,000. These exports went to over 20 foreign countries and states; but the United Kingdom and Germany absorbed about one-half of the total.

UNIFORM MACADAM SPECIFICATIONS in New Jersey is said to have been one of the chief objects of a conference of county engineers in that state. The New Jersey Association of County Engineers was organized, with Mr. James Owen, M. Am. Soc. C. E., of Montclair, as president; Mr. Robert Meeker, of Plainfield, as secretary; and Mr. Joshua Doughty, Jr., of Somerville, as treasurer.

THE HEATING AND LIGHTING ARRANGEMENTS of Symphony Hall, Boston, Mass., constitute perhaps the most nearly perfect system that has yet been worked out. Cool air, drawn in from the top of the building through a large shaft, is forced by electrically driven fans over two coils of piping aggregating 1,900 sq. ft. of heating surface. These pipes are supplied with exhaust steam from the engine room, and the temperature of the air may be regulated with great nicety. In hot weather chilled water may be passed through the pipes in place of steam, so that the plant affords both heating and cooling facilities. The warm or chilled air (as the case may be), after passing over these coils is forced by electric circulators through perforations which are worked into the design of the ceiling of the auditorium. The fresh air then circulates throughout the auditorium and goes out through registers placed in the first and second balconies and on the floor of the hall. In this way the entire auditorium is uniformly and thoroughly ventilated and either warmed or cooled. This system of ventilation is operated by five electric motors of 30, 22. 7, 3 and 2 HP., respectively. The ventilating shaft from the roof also serves as a conduit for the electric light and power wires. The seating capacity of the hall is nearly 2,600, the floor seating 1,400 and the first and second balconies about 600 and 500, respectively. The entire building is thoroughly fireproof and is moreover supplied with sixteen separate exits. The power plant of the building consists of three Babcock & Wilcox boilers, aggregating 600 HP. and furnishing steam at 80 lbs. pressure, and three horizontal Ames simple non-condensing engines, direct-connected to Westinghouse generators. Two of these units are of 200-K-W. capacity and the third is of 50-K-W. capacity.

AN AUTOMATIC ELECTRIC CABLEWAY.

The great utility and wide applicability of devices for transporting materials in light loads over short distances is demonstrated by the rapid growth in recent years of companies manufacturing aerial cableways, conveyors and light industrial railways. At present there are 25 firms making mechanical cableways, and one manufacturer alone has more than a thousand lines in operation. Up to the present time, cableways and cable tramways, or similar mechanical devices, have practically monopolized the field. An exception should be noted in the limited use of pneumatic tubes for transporting small parcels.

That electric traction possesses possibilities and advantages in the transportation of light loads which are not found in other methods was recog-

Fig. 1.—Automatic Electric Cableway Car, or Telpher. Made by the Consolidated Telpherage Co., 20 Broad St., New York City.

nized early in the development of the electrical industries. The subject was taken up more than a dozen years ago by Prof. Fleeming Jenkin, of Scotland, who constructed an automatic electric cableway, with which he experimented quite extensively. To him we are indebted for the word "telpherage," which he defined as, "The transmission of vehicles by electricity to a distance independently of control from the vehicle." Professors John Perry and W. E. Ayrton, of London, also devoted some time to the matter; but the enormous development of the electric street railway and electric power and light distribution soon absorbed the attention of electrical engineers the world over and telpherage was lost sight of. Moreover, there was not that prospect of great reward to spur the efforts of inventors that existed in the larger field of street railway work.

The development of the street railway, however, has solved most of the problems of telpherage, and the matter is now again being taken up. Fig. 1 represents a telpher, or automatic electric car, in daily use at the works of the Crocker-Wheeler Co., at Ampere, N. J., where a line of about 800 ft. has been installed. It is used for carrying castings from the brass foundry to the machine shop, and has been designed for a maximum load of 250 lbs. A diagrammatic plan of the carriage is shown in Fig. 2. Two grooved wheels resting upon the carrying cable are directly connected each to two small electric motors. A trolley carried upon a short pole upon the upper side of the carriage takes current from the trolley wire suspended about 15 ins. above the carrying cable, which forms the return. To the frame of the carriage is suspended a differential chain hoist for raising or lowering the load. The small cord hanging from the carriage is used to operate the reversing switch controlling the motors.

The carrying cable and the trolley wire are supported upon hook-shaped brackets, one of which may be seen at the right in Fig. 1. These in turn are carried by a cable supported by the cross arms of the poles. This cable is hung approximately in the form of a parabola, while the carrying cable is straight. This method of support does away with the excessive grades and bending of the carrying cable which would occur if the latter were directly attached to rigid supports.

A multiplicity of motors upon a single carriage has been adopted for the following reasons: In case of an accident to one of the motors the others will still be able to bring the carriage in; the necessary clearance and size of hangers is reduced; with only a few standard sizes of motors, a large number of sizes of telphers can be constructed by varying the number of motors per car. Each motor has its own shaft, which extends half way through the running wheel, and is held by a set screw and feather. By loosening this set screw and four bolts a motor can be quickly removed for repair. The motors are enclosed and weather-proof. The line here described has been in operation for several months and during all kinds of weather and has given no trouble.

The speed of the telpher is reduced at curves by a suitable arrangement of resistances. The running wheels travel upon a curved angle iron at points of curvature.

The devices for starting and stopping at the termini are very simple. The telpher runs upon a dead section and slows down of its own accord. After throwing the reversing lever upon the carriage it may be started back again by pressing a spring switch, which makes the terminal section live. Various automatic devices can be added where needed. A telpher can be made to run to the end of a line, automatically reverse and return. Its approach can be indicated at any point by the lighting up of lamps. Automatic switches may be provided at crossovers to make collision impossible. It may be so arranged upon a branching line that the cars will automatically select the proper switches. Automatic block systems may be installed, together with all the other automatic arrangements that are so easily made with electrical apparatus.

The power consumption per gross ton transported has been found to be about the same as upon street railways running without intermediate stops; that is, about 15 lbs. pull per ton is required. The limitations in regard to grades are also the same as in electric railway practice. The line here described is operated at a maximum speed of 12 miles per hour, but under suitable conditions a much higher speed could be obtained. When desirable, trailers can be attached to the motor car to increase the load carried per trip.

The advantages of this system as compared with mechanical cableways are its flexibility, its adaptability to long lines or rapid transportation, the possibility of having as many curves in the line as may be desired and the small consumption of power. On account of its automatic features it would possess various advantages depending upon the requirements to be fulfilled in a given case. It is best suited for level districts, while the cableway systems have had their greatest usefulness in mountainous regions, where no other form of mechanical transportation has been found practicable.

For the information here given we are indebted to the builders of the above plant, the Consolidated Telpherage Co., of 20 Broad St., New York City. They are at present installing a number of electric cableways in various parts of the country and they have also worked out a system of surface and underground telpherage.

A NEW GARBAGE FURNACE AT ATLANTA, GA.

One of the most recent candidates for public favor in the way of garbage furnaces has been in operation at Atlanta, Ga., for about a year. It was built by the Lester Furnace Co., named from Mr. J. F. Lester, the president of the company, and the man who conceived the ideas on which the furnace has been developed. Mr. Lester was formerly a dealer in books and stationery, in Atlanta, but for some months past has been located in New York city.

Associated with Mr. Lester in the company, and placed in charge of the construction and operation of the furnace, is Mr. J. A. Forsyth, to whom we are indebted for courtesies extended to a representative of this journal, who visited the furnace on Dec. 17, 1900. Mr. Forsythe states that some of his ideas are embodied in the design of the furnace.

Before the present furnace was placed in service, in December, 1899, an earlier one had been built for experimental purposes. During the year 1900 the company burned such garbage and night soil as the city brought to the plant for the sum of $1,000 per month, a figure accepted for the sake of giving the furnace a thorough practical test. No contract for the disposal of garbage and night soil in 1901 had been made up to Jan. 25. The city owns some 140 acres of land outside the city limits, in which it used to bury garbage and night soil, and on which it operated a Dixon furnace for a number of years. The haul was long and the fuel bill was high; otherwise, it is said, the Dixon furnace gave satisfaction.

The Lester furnace is located near the center of the city, close by various industrial plants and within about one-fourth mile of a residence section, the latter being on a higher level than the furnace, which is in quite a ravine.

The furnace is in six sections, designated as chambers, having a rated capacity of 25 tons each. It is proposed to add two more, to give a reserve. The furnace is on the down-draft principle. The garbage is fed into a large compartment, 18 × 12 ft. in plan, from which it falls, and is raked down into three smaller parallel compartments, beneath, each about 5 × 12 ft. The large upper chamber is covered by an arch of 18-ft. span; and the smaller ones by arches of some 5-ft. span, the latter being perforated by omitting some of the bricks and readily serving as an upper grate. The long, narrow, lower compartments have iron grate bars, beneath which are ash pits. At the back end of each of the small grates is a bridge wall, over which the gases pass to a flue leading to a coke fire at the outer end of the furnace. There are four of these fires, two

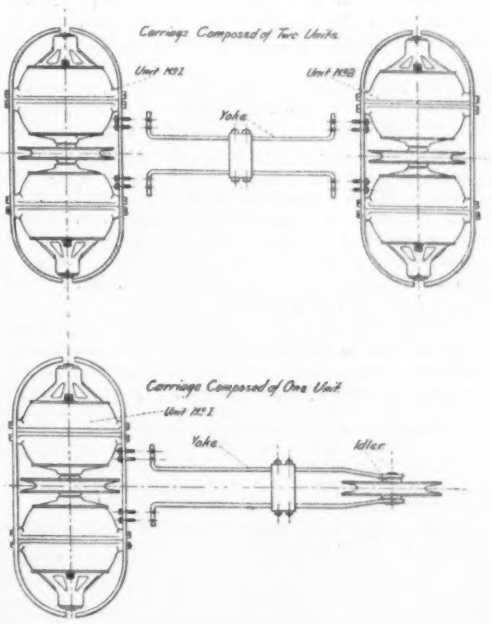


Fig. 2.—Plan of Telpher.

at each end, or one for the three chambers, making up each quarter of the whole plant. These coke fires are kept pushed well back towards the flues leading to the central stack.

The stack is 126 ft. high. It has an interior diameter of 6 ft. at the base, and also at the top, but there is an intermediate portion of peculiar cross-section, said to give a double vacuum. The base of the special section is 18 ft. from the bottom, and here the chimney begins to contract, until at 27 ft. it is 5 ft. in diameter. It then expands back to 6 ft. at 36 ft. from the base, when it abruptly enlarges to 7½ ft. Then it begins to

contract again until at 48 ft. from the base it resumes its normal diameter of 6 ft.

The location of the furnace is such that the wagons are taken from the street to the dumping floor with ease. Here the garbage is dumped into hopper-shaped storage bins, made of wood. Each of the six bins will hold 25 loads of garbage. Wooden gates control the outlets of the bins. Chutes lead from the gates to the charging holes of the furnace, on the second floor. Besides the garbage chutes leading to each main chamber there is a 3-ft. vertical steel or iron chute over two of the chambers, through which dead animals may be dropped from above. Over the four other charging holes are 4 × 15-ft. steel cylinders, with inverted truncated cones at the bottom, fitted with 10-in. straightway valves. There is a partition down the center of each cylinder. Into these the night soil is emptied from the dumping floor above. The more liquid portion is strained through a wire basket and discharged into one side of the cylinder, the strainings and the more solid part of the contents left in the tank going into the other side. The night soil from these cylinders is let into the furnace in doses, alternating with the garbage; the more solid portion through the gate valves, and the liquid part through hose, the latter in small quantities.

The night soil is brought to the furnace in heavy wooden casks, fitted with cast-iron lids and rubber gaskets. A rod extends up through the center of the cask and through the cover, with a wrench nut on the upper end for securing the lid.

The amount of refuse of all sorts treated during the year 1900, according to the records kept by the city, was 41,245 tons, or an average of 113 tons per day for 365 days. Of this, 21 tons per day, or nearly one-fifth, was night soil. The casks in which the night soil is collected hold 20 gallons each, when full, so the quantity of night soil may be stated in fairly definite terms, if anything like an accurate record of the number of casks emptied is kept; assuming the casks to be full. The garbage and other refuse brought with it is assumed to weigh 1,000 lbs. a load, as an average of wet and dry. This average is based on weights taken in December, 1899. Ashes are not supposed to be mixed with the garbage, but almost every other sort of house refuse is put in the garbage cans.

The principal fuel required, aside from the refuse, is the coke for the fume consumers, or the four little furnaces over which the gases pass before they go to the chimney. The amount of coke used for this purpose is placed by Mr. Forsythe at two tons a day, seven days in the week, or ½-ton per fire. The coke costs $4 per ton. Aside from the coke, the only extra fuel used in the last three or four months was stated by Mr. Forsythe to be 21 tons of coal and 7 cords of hard wood used only in wet weather.

About 10% of the material burned, it is estimated, has to be removed as cinders and ashes. These are dumped close by. Altogether, 15 laborers are employed, some in a day and some in a night shift. The labor bill, including some repairs, but no salaries, is about $150 a week. Quite a bit of stoking is required to get the material through from the upper to the lower combustion chamber.

The top of the chimney, on Dec. 17, 1900, showed only a small amount of light smoke. It was Monday morning, and the fires were just being started. No odor was observed near or in the furnace building, except close at hand, from material being dumped. There seems to have been very little complaint of odors from the stack.

The chambers are filled and got to burning during the day and the principal burning is done at night. The fires die down over Sunday, except that the coke fires are kept going constantly.

Mr. Geo. M. Hope, the chief sanitary inspector, expressed satisfaction with the furnace, and so did some of the other city officials. We are indebted to Mr. W. T. B. Wilson, Assistant City Engineer, for aid in securing information for this article.

HYDRAULIC SHIELD TUNNELING ON THE MELBOURNE AND METROPOLITAN SEWERAGE SYSTEM.*

The shield tunneling carried out in Melbourne is notable on account of the number of sewers of small diameter built in this way, for the novel methods adopted for lining the tunnels, and for the variety and extent of the soft ground to be passed through.

The descriptions and particulars given are taken mainly from Melbourne Sewerage Works and from the writer's own experience. The source of the information is given in all other cases.

The importance and success, indeed, almost, it might be said, the necessity, of this system for carrying out the tunneling for the Melbourne sewers, is manifest to everyone having knowledge of what has been done. The extent of Melbourne shield work is indicated by the table below, and it is safe to say that were the whole of the sewerage works to be carried out with present knowledge, this list would be much longer.

The first introduction of the shield in Victoria was for the purpose of constructing the Hobson's Bay main sewer with cast-iron lining, under the Yarra at Spottiswoode, but the first shield tunneling was done with concrete block lining at Port Melbourne. Though difficulties were met with, little experience was needed to meet them, and the use of the shield may be said to have been immediately successful, for the troubles of the earlier works were certainly owing to undue delay in adopting the use of air compressed to pressures approximating to those of the water in the soil to be tunneled through. Naturally with present experience more use would have been made of it in earlier work. For in every case the use of the shield and a proper air pressure have practically removed the difficulties due to water and running ground.

THE SHIELD.

The shield consists generally of an iron cylinder about four to five times the length of the lining rings to be used with it. There is a diaphragm, or bulkhead, fixed in it at some distance from about 1 ft. to half the length of the shield from the forward end, having one or more openings in it fitted sometimes with drop or sliding doors.

*A paper by George Henry Dunlop, C.E., read before the Victorian Institute of Engineers, Aug. 3, 1898, and reprinted from a special edition of the "Building, Engineering and Mining Journal," of Melbourne, Victoria.

Contract.	Kind of Lining.	Diameter of sewer. Internal ft.	Diameter of sewer. Internal ins.	Diameter of sewer. External ft.	Diameter of sewer. External ins.	Length of rings, ft.	Length of rings, ins.	Length of rings, ft.	Length of rings, ins.	Length in feet.	Amt. work done in compressed air in ft.
Hobson's Bay main, Sec. 1	Cast iron	9	0	11	0	1	6	& 2	9	900*	500
" " " " 1	" "	9	0	11	0	2	9			633	Very short
" " " " 2	Concrete blocks.	8	6	11	0					1,300	
" " " " 2	" "	8	9	11	3	1	6½			4,900	Nil.
" " " " 2	" "	9	9	11	6					3,000	
" " " " 3	" "	8	0	10	6	1	6½			960	700
" " " " 4	Cast iron	4	3	5	9	1	3			2,070	1,430
" " " " 4	Bluestone	4	3	5	10½	1	6½			1,290	Nil.
" " " " 5	Bluestone	4	3	5	10½	1	6½			1,327	Nil.
" " " " 5	Cast iron	4	3	5	9	1	9			1,611	1,486
" " " " 5	Bluestone	4	3 and 5	5	10½ 8½	1	6½			1,200	Probably nil
South Yarra main, Sec. 1	Bluestone	6	9	9	0	1	6½			1,760	Nil.
Richmond main, Sec. 1	Cast iron	4	3	6	0	1	6			704	494
Melbourne main, Sec. 1	" "	3	3	5	9	1	6			1,440	450
" " " 1	" "	3	3	4	10½	1 to 2 varying.				3,440	Nil.
" " " 1	Concrete blocks.	3	3	5	9	1	6½			860	Nil.
" " " 1a	Cast iron	3	3.3			?	?			247	247
North Yarra main, Sec. 1	Bluestone	8	6			2	4			496	
" " " " 1	Cast iron	8	6			1	6			387	Nil.
" " " " 4	" "	7	9	9	9	2	0			5,280	Nil.
" " " " 5	" "										
" " " " 6a†	Wood	7	6	10	6	2	0			1,270	Nil.
" " " " 6a†	Wood	8	9	9	9	2	0			1,990	...
Total length										37,145	

*Section under Yarra; about 500 ft. subaqueous.
†Alternate tenders called for wood and cast-iron lining; tunneling nearly completed.

In front of the bulkhead there may be horizontal and vertical longitudinal partitions forming compartments into which the soil is forced when the shield is shoved forward. Behind the bulkhead around the shield are fitted hydraulic jacks, the piston heads abutting on the end of the already constructed tunnel. By these the shield is forced forward after the rings have been built within the rear end of the shield.

Five types of shield are shown in outline in Figs. 1 to 5. Fig. 1 shows the type of shield used here for small sewers. It was built of diameters from 4 ft. 11 ins. to 6 ft. It had one opening in the bulkhead from 2 ft. 6 ins. to 3 ft. 6 ins. square, fitted with guides for drop planks. Some designs were of the Greathead type, using a combination of cast and wrought iron; others were built entirely of wrought iron or steel of ⅛-in. and ⅜-in. thickness.

The Clark design of shield is shown in Fig. 2. Seven shields from 10 ft. 9 ins. to 11 ft. 6 ins. in diameter were built. It was designed to tunnel through bad ground without compressed air, and it worked successfully, especially in silt.

A type of shield suitable for bad ground, but having the bulkhead nearer to the front is shown in Fig. 3. It is suitable for good ground also.

Fig. 4 shows a shield of medium size, having the bulkhead towards the middle of the length. It presents less resistance at the face when being pushed into the ground and provides more room for the workmen or for earth than No. 2. The Mersey type of shield is shown in Fig. 5.

The shield with the bulkhead about 1 ft. from the cutting edge, especially the Greathead shield, has been called in Great Britain, the assisted shield,† as it has been largely used there with a system of advance timbering. In this practice the ground is excavated and timbered for a short distance in front of the shield, the forward end of the timbering resting on props, the rear end resting on the front end of the shield. The shield with compartments in front has been called the independent shield.* It has usually had the bulkhead further from the cutting edge and sometimes at the middle of the length of the shield, with partitions in front of the diaphragm. The object of the partitions is to divide up the "face" in order to facilitate excavation, and the compartments provide room for the earth forced in during the advance of the shield for a ring length, so that it is not necessary to excavate in front of the cutting edge. The nomenclature, assisted and independent shield, was not entirely accurate for Melbourne procedure. Here the assisted shield was frequently used independently of advance timbering, and the independent shield with it.

In the small shields of about 6 ft. diameter there is neither space nor necessity for compartments and they are not used. And in order to allow as much room as possible for the men within the shield, and to keep the length as short as possible, the bulkhead is necessarily put within about 1 ft. of the cutting edge (Fig. 1).

The operation and suitable construction of the shield may be described for hard ground, wet silt and sand.

In hard or firm ground the bulkhead will be placed near the cutting edge, and the ground will be excavated for about an average distance equal to a ring length ahead of the shield, the ground being taken chiefly from the center of the face. When the shield is shoved forward, the cutting edge will break down a large amount of the ground ready for shoveling. A large door in the bulkhead is advisable.

In work here in silt there has been no apparent advantage in having the bulkhead far from the cutting edge, but in the larger shields partitions in front are advisable, especially in soft silt, in order to control the "face." The shield will be shoved into the ground and the spoil shoveled as it squeezes up to or through the doors. The silt has been pressed, sausage-like, 2 ft. through the doors of a shield with the bulkhead 4 ft. from the front. Soft ground, such as sandy clay with water, will squeeze similarly though not so freely as soft silt.

The most difficult material to deal with is fine running sand, especially if there be hard material in the bottom through which the shield cannot be forced. It is impossible to force the shield through sand, as through silt, without undue pressure. The face must be excavated back. Unless the pressure of the water is so great that compressed air is necessary or at least distinctly advisable, it is not difficult to excavate out as far as the front of the shield. There should then be sufficient room in the compartments to hold the spoil for the shove for a ring length. When working in this way, the ring length should be short, not more than 18 ins. In the Graham St. shield-tuneling at Port Melbourne, the shield (Fig. 2) was 8 ft. long, 10 ft. 9 ins. diameter, with the bulkhead in the middle of the length. There were four compartments and plates tapering from the full diameter to the edge, to about 6 ft. diameter at the bulkhead, where there were four openings, each about 2 ft. square, fitted with drop doors. Drop planks fitting in channels beside the doors would be about as effectual as the doors, and would permit a shield and required more compression than could be obtained except with larger and more convenient opening. This type of shield was most effective in compressing the silt, but the sand would not compress. The conical form

*Leitch, Trans. Inst. C. E., CXXV., 377.

of the front compartments presented too much resistance to the silt. And although the chambers 4 ft. deep might be full of sand, at times the water would rush through, carrying slurry. Finally it became necessary to employ air pressure to enable the chambers to be properly cleared. The distance of the bulkhead from the front of the shield was then found to be a source of considerable inconveniences when excavating. The rings were 18 ins. long, and when shoving in the running sandy ground, and especially before compressed air was used, extreme difficulty and great delay were continually experienced in pushing the shield through the last few inches. Frequently the chambers were cleared twice for each ring length, and sometimes it was necessary to clear them to allow the shield to move the last 1 or 2 ins. For a considerable distance here, there was a layer of about 2 ft. of cemented gravel in the bottom, with silt and sand above. The horizontal front partition was kept pressed into the face, and, notwithstanding the running ground in the top of the excavation, the men were able to go safely under the partition so as to pick down the gravel in front of the cutting edge.

For use in cases where variable ground will be met with, every shield large enough to allow subdivision of the front into compartments, should be arranged so that partitions and doors can be bolted in and removed at any time. Thus the Greathead type of shield used for the Yarra tunnel at Spottiswoode was subdivided in front into four compartments in this manner, by the second contractor, and the partitions were removed when the tunnel had been carried forward some distance into firm clay. There was considerable inconvenience in working with them and they possibly were at no time entirely necessary. They doubtless gave a feeling of security to the workmen.

The position as to the type of shield may be summed up in this way: The short front type of shield is most suitable in good ground. Bad ground should be made good by the use of compressed air. But if the material is very soft or sandy, or if sufficient air pressure cannot be obtained, front partitions will assist in holding up the face. But the front should be arranged to give as much working-room as possible for the men. The horizontal partition in variable ground is specially valuable. Finally, in bad ground, where air pressure cannot be used, partitions should be used in the larger shields. In this case the principal matter for consideration is the position of the bulkhead. The writer favors putting it about a ring length from the cutting edge in shields of medium size, such as 10 ft. diameter, and leaving the whole front clear of rams for the spoil forced in when shoving into the ground (Fig. 3). In very large shields the Hudson River type would be adopted (Fig. 4). The matter largely depends on the size of the shield, and consequent possible size of the compartments. If the compartments must be made so small as to prevent a man from working with reasonable ease, the bulkhead will be placed forward so that the man can excavate standing behind it. If the compartments are large enough for a man to work freely in them, the bulkhead may be placed well back, say 4 ft. from the cutting edge, so as to leave full room for the man to work in the compartment, and for this purpose at least 5 ft. of height is necessary, and 6 ft. would be better. The larger size of shields such as that at the Hudson River tunnel permit this. There has not been apparently any case in Melbourne where the front large compartments would have been necessary or advantageous if full air pressure had been used.

A projecting circumferential hood and partitions were bolted in front of a shield under the Stoney Creek. The effect of thus prolonging the upper cutting edge by the hood was to allow the face to be battered so that it would stand better, and to cut off any inrush from the top by keeping this hood cutting edge always thrust into the solid ground.

The Mersey tunnel shield (Fig. 5) has a curved bulkhead 2 ft. to 3 ft. from the cutting edge, with small openings for access to the face. These small openings caused the work of excavating to be slow. Afterwards an enlarged opening was made in the curved bulkhead, and a second bulkhead rising to mid-height was fitted behind it, as shown by the dotted lines, with a movable trap-door closing the top opening across to the front diaphragm. This second bulkhead was put in to check sudden rushes of sand and water. Here the horizontal partition in front, together with a ready means of closing the top openings, effected the same purpose. The Mersey shield was 10 ft. 3 ins. in diameter. If this were considered too small to have four front compartments, the horizontal partition could be placed 6 to 9 ins. below the middle, and the upper vertical partition alone used with it.

In the construction of the outer shell there are two practices. Either it consists of two plates of equal thickness breaking joint, or of one plate with cover-plate joint. The second is undoubtedly the better construction. The first would require the most accurate abutting of the plates at the joint. The writer has examined a shield built of two plates, and found in several places one plate broken and the other not. This showed, as might be expected, that they did not act in unison.

Projecting teeth for breaking down the ground in front of the cutting edge have been proposed but not used here. They have been used in England successfully.

Two special types of shields, neither of which has been used in Melbourne, may be briefly referred to. These may be called "non-circular" and "roof" shields.

The use of the non-circular shields has been discussed both in England and Victoria. It will not be difficult or unduly expensive to secure strength and stiffness—at least, in small shields necessary for oval sewers. The difficulty will be to prevent rolling. In discussion at the Institute of Civil Engineers* it has been contended that with a non-circular shield there will not be the same facility for rolling, as there will be resistance both from the ground and the lining. Their successful use, even in good ground, would be very uncertain, and only slight advantages would be gained.

The roof shield consists of an overhead arch pushed forward by hydraulic jacks. The shield rests at the sides on longitudinal timbers or beams upon which it rolls or slides. It has been successfully used in America and France.† The use for this class of shield must be limited.

FITTINGS AND POWER.

No considerable improvement has been made, or appears necessary, in the arrangement of rams and fittings of the Greathead shield, described and illustrated in connection with various tunnels.

Each ram should be fitted so that it can be thrust or withdrawn independently of the others, and, as in the Greathead shield, so that the whole can be simultaneously withdrawn, when the stroke is completed, by the reversal of one valve. In the Greathead shield—and especially in the advance timbering system of working—manual power is used to operate the hydraulic pumps fixed in the shield. This system was found unequal to the requirements of Victorian work, and the writer has not had experience with it. Here, with some inconsiderable exceptions, the water for the hydraulic jacks, at pressures up to 2 tons per square inch, has been conveyed from pumps at the surface through 1 and 1⅛-in. piping to the shield. A telescopic fitting with a stroke of about 8 ft. is attached at the shield. Manual power might be used where very little power would be required, or where the small amount of work to be done made it desirable to reduce the cost of plant. But it seems fair to say generally, that the power pumps are preferable in all cases. Manual pumps take up too much room in very small shields, and they entail hard labor on the workmen in the larger ones, and delay in all cases. While the shield is being shoved forward, most of the men can be otherwise engaged, as in preparing for building the ring and getting the lining materials forward.

EXCAVATION.

Three processes are adopted in regard to the excavation —advance timbering, or the assisted shield method; clearing away a space in front of the shield without timbering —at least, without any complete system of timbering; and the independent shield system, in which the shield is forced into the earth which is excavated within the shield.

The only case in which advance timbering has been adopted here as a regular system was at the Yarra tunnel at Spottiswoode, during the earlier half of the work. There the shield, hand-pumps, and system of working was substantially that used in the Glasgow tunnels,* except that no heading was carried in advance, each 2-ft. 9-in. ring-length being taken out ahead of the cutting edge successfully. With full air pressure equal approximately to the hydrostatic pressure this plan was practicable, but slow and costly. It was afterwards amply demonstrated that with 18-in. ring-lengths, and proper air pressure, this complete system of timbering was not required. In the system in practice at the Glasgow tunnel it is difficult to see the use of a shield, and particularly the strong cutting edge. Here the advance timbering system has not been found necessary.

At the Yarra tunnel, in the second contract, the next system of excavation was practiced. In front of the bulkhead there were bolted in one vertical and one horizontal partition, projecting about 2 ft. All the ground above the horizontal partition, converted by the full air pressure to good standing, firm, sandy clay, was excavated away, especially in the inferior, sufficiently to allow the shield to be pushed an 18-in. ring-length. Timbering was not necessary, but light temporary timbering sufficient to steady the face could have been used, consisting of boards across the face with light temporary props against the bulkhead. These props could be removed, or would be broken as the shield was pushed forward. (This was done when necessary at Graham St., Port Melbourne.) Below the horizontal partition the ground was coarse and fine sand. Above the level where the air and water pressure balanced, this stood well; below that level light timbering was adopted to hold back the wet running sand around and in front for the bottom 2 or 3 ft. to enable the sand and the rock boulders to be removed. The shorter ring-lengths greatly facilitated progress, though the longer rings would probably have been quite safe, especially if the 2-ft. 9-in. advance were made in two stages. Afterwards, in firm clay, when all partitions had been removed, the ground was excavated far enough ahead of the cutting edge, but to a smaller diameter, to allow the shield to be pushed forward for 2-ft. 9-in. ring. In this way from one-third to one-half of the clay would be broken down for the shovelers.

The plan of forcing the shield forward and allowing the soft material, especially silt, to squeeze through the door, was adopted in several contracts. It may be said generally that it is a suitable method only in silt.

DIRECTION.

To ensure accuracy of line and level is difficult, especially in bad ground. It should be most easy in the advance timbering method of excavation, and, possibly, this is partly the cause and justification for that system.

Simple but frequently repeated observations (depending,

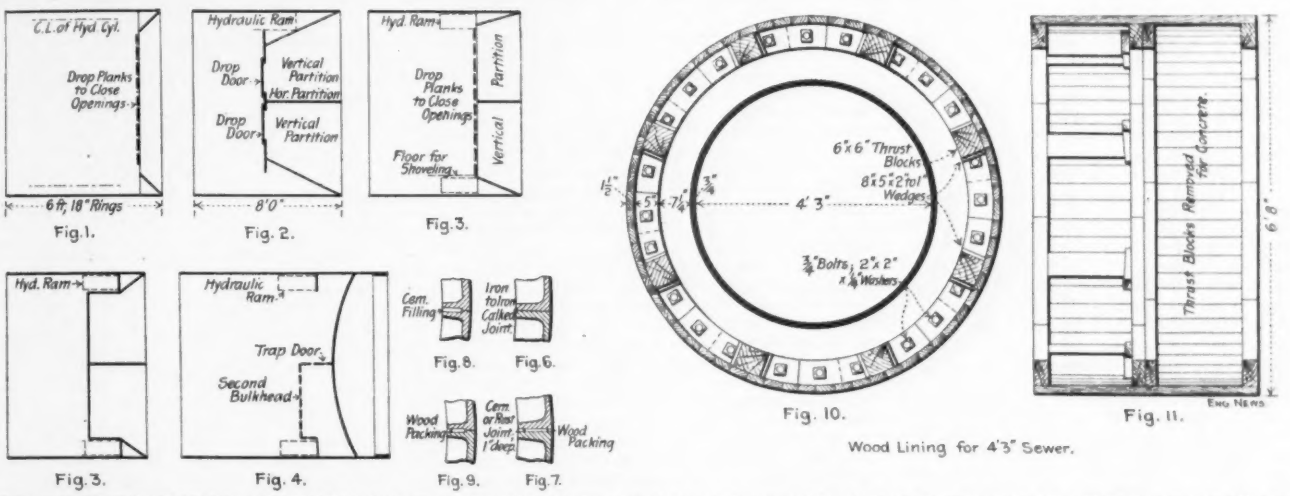


Fig. 1. Fig. 2. Fig. 3. Fig. 10. Fig. 11.

Fig. 3. Fig. 4. Fig. 9. Fig. 7. Fig. 8. Fig. 6.

Wood Lining for 4'3" Sewer.

FIGS. 1-11.—DIFFERENT TYPES OF HYDRAULIC TUNNELING SHIELDS AND WOOD LINING, MELBOURNE AND METROPOLITAN SEWERAGE SYSTEM.

*Trans. Inst. C. E., Vol. CXXV., p. 107.

†Engineering News, Jan. 9 and 16, 1892; July 9, 1896; June 24, 1897.

*Engineering, LXII., 574; Trans. Inst. C. E., CXXV., p. 383.

of course, on the rate of progress) are necessary to determine the position of the shield and its parallelism with the center line. Accurate grade—at least, on sewer work—is much more important and more difficult of attainment. No rules can be given; it is simply a matter of care and observation. In soft ground the shield must usually be kept with a considerable rising grade to allow for the continuous settlement that takes place. A large number of powerful rams materially assist in keeping and in rectifying the course of the shield. There should be a ram for every 3 to 4 ft. of circumference of shield, with 6-in. to 7-in. cylinders. The top ram may well be omitted, as less power is required there, and more head-room will be left, especially in very small shields, for working and erecting the key piece.

Two special matters only need be dealt with. The shield has a tendency to roll. This is due to some peculiarity of the construction and sometimes it may be due to the ground. Rolling may be prevented and sometimes rectified by incompletely excavating the upper portion of the face on the opposite side.

Rolling is stated by Greathead* to be due simply to the combined thrust of the hydraulic presses being not parallel to the axis of the shield, and he has suggested that some of the jacks be fitted so that their direction of thrust may be adjusted. Such an arrangement would certainly be necessary if it were attempted to use a non-circular shield.

In hard ground, it is difficult to turn the ordinary shield, for it cuts out exactly its own space; and the material being incompressible, it cannot be deflected in its course. In one case here it was necessary to pick away the ground to an approximately oval shape larger than the shield to allow it to turn either in a horizontal or vertical direction and to impose special resistance by strong struts from the face to the bulkhead on the side towards which the shield was to be turned. Adjustable steel cutters are provided for this purpose on the Greathead shield, but the method described, though troublesome, was used here.

THE LINING.

The lining used with the shield should be strong, impervious to water, easy of erection, and require as little underground work as possible while working the shield. The construction should be such that the joints will not wash out with water, and the ring will not readily yield to unequal pressures. The various systems used in Victoria will now be described.

CONCRETE BLOCKS.

The first lining used in Melbourne shield work consisted of concrete blocks set in cement. The following dimensions were adopted for an 8-ft. sewer at Port Melbourne. The rings were 18½ ins. long, containing 17 blocks 18 ins. long, and 22 blocks of half that length, equivalent when set to 11 of the former. The lining was 15 ins. thick, having 1½ ins. of outer rendering, and 12¾ ins. of concrete in the block, and a final ¾-in. rendering when in position. The blocks were made in tapering molds, with the sewer face of each block underneath, and the 1½ ins. rendering was applied while the concrete was quite fresh.

The concrete block system of lining was fully tried, and it must be admitted that it only partially realized the anticipation generally held when it was first introduced. Its advantages were such as to make it eminently suitable to our circumstances and worthy of trial. It was cheap, and if it could be effectively constructed it would be most reliable and durable. But it had two radical inherent constructional defects. As the shield was pushed forward, the joints, partially set, were broken by the pressure used in shoving the shield, and by the alteration of form of the ring of blocks in passing out of the shield into the larger area of excavated ground. No means to sufficiently overcome these defects have yet been brought forward. If they could be overcome the merits of the system would be great, and its extended success assured.

The remaining difficulties were remediable. The water washed out the fresh joints, the block sometimes crushed under the heavy pressures of the hydraulic jacks, and as the work was practically completed as the shield advanced any departures from the proper level or direction could not be corrected without reducing the size of the sewer. In most cases the use of sufficient air pressure would prevent the joints washing out until set. The crushing of the blocks could be prevented by a better distribution of the pressures, by increasing the end areas of the blocks, and by increasing the strength of the concrete if necessary. The head of the ram pressed against the middle of a "pressing beam," resting against the ends of blocks. The short toothings were brought up by 4½-in. "toothing blocks." The arrangement could be improved. Even with 12 × 6-in. pressing beams there would necessarily be unequal pressures on the blocks. And it was difficult to get the toothing blocks to accurately fit and give an equal bearing for the pressing beam. Should they be too small, the long toothing blocks might be crushed, while the short toothing blocks might be unloaded. By diminishing the number of the blocks in the ring, or increasing the number of hydraulic rams, there could be arranged a ram for every three blocks, and upon these the pressure could be more equally distributed. The shield could be pushed forward without exceeding a thrust of 36 tons by any one ram, and this thrust could be distributed so that not more than 18 tons could be imposed on any one block. This pressure in working conditions of blocks of suitable size would not be excessive for the few repetitions to which they would be subjected. Bluestone blocks were used in conjunction with the concrete in order to prevent crushing.

The difficulties of securing correct alinement and level were mainly due to the bad ground, and could be proportionally removed by the use of compressed air.

*Trans. Inst. C. E., CXXIII., 107.

BLUESTONE BLOCKS.

Bluestone blocks were suggested instead of concrete for the sewer under Stoney Creek in order to get greater strength to resist the thrust of the jacks. Their use presented no other gain, and could not obviate the inherent defects of the system. Under the particular circumstances regulating the respective prices of stone and concrete blocks in late years, the bluestone would cost about one-half more than the concrete blocks delivered at the shaft, and as the strength would be very much greater, the bluestone is relatively cheaper. But under past normal conditions in the stone trade, the bluestone blocks would have cost from two to three times as much as concrete blocks, and as a minimum stable thickness would be necessary, the strength of the bluestone would be too dearly purchased.

One special case of successful work may be given. For part of the length of a 4-ft. 3-in. sewer to be constructed of brickwork there was about 30-ft. of wet sand, with 3 to 4 ft. of excellent clay above the crown of the tunnel. In timbering this ground about 18 ft. at least of the clay above the tunnel would necessarily be broken down and the remainder could not be held up as tightly as if would be over the shield. The water would come through, disintegrate the clay, and "runs" of sand would follow. It was decided to abandon the ordinary timber method in favor of shield tunneling. Bluestone block lining was selected. There were 18 stones 18 ins. long and 9 ins. thick in each ring, set in 2 to 1 cement mortar with 4½-in. toothing. All the blocks were of the full length, but the 9 lower blocks were larger, occupying 9-16th of the full circle. After the sewer had progressed some distance the following method of carrying out the work was adopted: Instead of building the ring within the tail of the shield, only three or five of the invert stones of a ring were built there, and the remainder of the ring, really the completion of the preceding ring, was built immediately behind the shield, the clay standing up unsupported for the length and time necessary to allow of this being done. In building in this way the spaces due to the thickness of the shield and any other vacuities were filled with sand packing. Thus, one of the already mentioned inherent defects of the block system could be overcome. No spreading deformation of the sewer took place, and excellent work was effected. Of course the circumstances were unusual, but the method selected was certainly a good one to meet them. In one or two places wet ground was met with, and the building of the ring was done within the shield. The defects of the system at once asserted themselves.

CAST-IRON LINING.

In the ordinary system of cast-iron lining the length of ring has varied from 12 to 33 ins. The most suitable length will be from 18 to 24 ins. Long plates are not economical with the same design of flanges, and lengthening of the ring simply reduces the proportion of metal in the circumferential flanges, where metal can be most suitably disposed to give strength to the lining.

The depth of the flange in inches is usually about 2 ins. plus one-third of the diameter of tunnel in feet; and the thickness of metal about 1 in. for 6 ft. diameter of tunnel and 0.025-in. for each extra foot of diameter. The circumferential length of the plate should be as great as is practicable for manufacture and erection, but the key piece should be short, only 9 to 18 ins. long. It is well to avoid a longitudinal joint in the bottom in wet ground, as it is difficult, if there is much water present, to fit it well, and afterwards to clean round it before concreting Cast-iron plates have usually been made of the same thickness throughout. It would be better to increase the thickness of metal at the flange angles, as in the St. Clair tunnel lining,* or to use brackets from the flanges to the plate, as in the Glasgow subway lining.†

The circumferential joints can be flat, with strips of tarred felt, or better, of soft wood, ¼-in. thick. Tarred felt was extensively used here. It is an excellent packing, except that it is too thin with unplaned joints. These strips should fit closely, especially at the ends, to prevent leakage. A small space should be left at the face to be calked if required to stop leakage, and it generally will be required. The longitudinal joints are more important. If, as is usually done, these joints are made continuous along the tunnel, the stiffness of the ring is dependent upon the rigidity of the longitudinal joint. The best joint then will be a machined joint, fitting coated metal to metal, and tightly held together by strong bolts well screwed up at about 6-in. pitch, and with brackets between each pair of bolts. These brackets will help to transmit any unequal pressure or any tensile stress from the flange to the plate and prevent breaking at the [illegible]. If the joint be not machined it will be made as first described for circumferential joints. This was the practice in Melbourne, and it is a good one, especially if soft [illegible] packing is used.

*Engineering, L., 576.
†Engineering, LXII., 574.

Different designs of joints are shown in Figs. 6, 7, [illegible] 9. In Fig. 6 a longitudinal machined joint, fitted [illegible] to metal, is shown, with a space for calking with cement, or for a rust joint. This is the best form.

Fig. 7 shows a good type of joint for general use [illegible] both flanges. A ¼-in. soft wood packing is placed between the flanges. This packing will tend to swell and so correct any slight inequalities in the fitting of the castings. It will be better, but not entirely necessary, to have the flanges, especially the longitudinal ones, machined. There should be a space of about 1 in. deep left for calking so that the lining may be made water-tight. This joint is stated to have been made entirely water-tight in wet ground in London, using iron cement for calking.

Figs. 8 and 9 show types used more particularly for circumferential joints. The joint shown in Fig. 9 has, however, been largely used between the longitudinal flanges with soft wood packing, into which hard wood wedges are afterward driven in order to make it tight.

In the East River gas tunnel, in New York, the practice of having the longitudinal joint continuous was departed from, in order to obtain a more rigid lining ring. The matter is discussed and some tests given showing the comparative stiffness of the two systems. An 18-ft. ring at the Hudson River tunnel flattened 3 ins. when erected on the ground. This result accords with local experience. At the gas tunnel two rings of 10 ft. 2 ins. diameter were bolted together, breaking joint, one ring being revolved two holes; when erected no flattening could be detected. With a measured strain of 16,000 lbs. applied along the vertical diameter, it shortened ½-in., and the flanges of the plates cracked. The advantages claimed for the system of breaking joints are rigidity, the prevention of a tendency for the plates to warp so that true joints cannot be made, and the retention of a more truly circular form of ring.

The rigidity and the truly circular shape of the ring are of great importance, and the breaking of the joints should be a superior plan in both respects, for in this way each plate becomes a cover plate over the joints of the adjoining rings. If the rings are tightly and strongly bolted together the lining must evidently be more rigid than when it depends for stiffness entirely upon the longitudinal joints. The shield and the iron lining are made circular and with from 1 to 2 ins. of difference in diameter. In building the ring with the lower half of the iron lining in contact with the shield, the ring has an initial departure from the circular shape, and defective bearing at the longitudinal joints. If now it were attempted to attach another ring, with considerable breaking of the joints, the rings would not fit accurately, and, unless the bolt holes were considerably larger than the bolts, they might not fit at all. Therefore, it becomes necessary to build the ring more accurately to the circular shape. The importance of the bolting of the circumferential flanges is greater when the joints are not continuous, and as the bolts do not fit the holes closely, their efficiency depends upon the tightness of the screwing up. There should be no special difficulty in arranging the rings to break joint.

Where, as in Melbourne, the longitudinal joints are continuous along the tunnel, the purpose of the bolts in the circumferential joints is mainly to draw and hold the plates together in order to ensure a close joint in all cases. If the rings be closed together by the hydraulic ram pressure, as can readily be done, the bolts only require sufficient strength to retain the plates in close contact. It is impossible to estimate what forces there may be tending to separate the rings, but it does not seem likely that they would increase more rapidly than the diameter of the tunnel. If, then, a constant pitch be adopted, it follows that the diameter of the bolt need not increase with the diameter of the lining. There does not seem any necessity for more than ⅝-in. to 1-in. bolts for any size of tunnel, and a man using an ordinary spanner will not overstrain a ¾-in. bolt. Unless, then, a greater length of spanner is insisted upon, there is no advantage in any case in increasing the size of the bolt, for its strength will not be utilized. The pitch should be from 6 to 12 ins., and probably 9 ins. would be about right. For the longitudinal joints the case is different, for the ridigity of the joint depends upon the depth and fitting of the flange joint, and the tightness of the bolting. This relates to the total strength of the bolting. The strength of each bolt may be whatever the spanner used will utilize. The size may be ⅝-in. for 6 ft. diameter, and ⅛-in. more per 4 ft. of increase, with 6 to 8-in. pitch, according to the class of the ground and strength of flange.

In a 5-ft. 9-in. sewer lining in Melbourne, the cast-iron rings were 15 ins. long, with 1-in. metal and flanges projecting 3½ ins. They were bolted together with ¾-in. bolts at 6-in. pitch. This lining collapsed in two cases under exceptional circumstances, mainly through the ground getting away underneath, and thus causing an undue strain in the lining. In this case, the iron and bolts both failed, but the cast iron much more extensively than the bolts. It was clear that fewer bolts would have sufficed to utilize the strength of the cast-iron plates. There were no brackets.

In designing and constructing sewers, especially in pumping schemes, it will be of importance to consider the extra cost to which it is advisable to go in order to exclude leakage. The expenses due to leakage will be extra cost of pumping, reduction of effective area of sewer, and general charges.

Suppose one mile of sewer 8-ft. in diameter costs £60,000, and admits 3,000 cu. ft. of water per hour. Estimating the cost of pumping 1,000,000 cu. ft. per day 1 ft. high at £30 a year, and taking the lift as 120 ft., the annual cost of pumping this leakage will be £260, and at 4% interest, this will represent a capital sum of £6,500, or about 10% on the cost of the sewer.

Again, assuming a velocity of 3 ft. per second, the discharge of the sewer will be about 540,000 cu. ft. per hour, of which 3,000 cu. ft. will be leakage, being in this case 1-180th of the whole. And this will apply to every succeeding mile of the sewer to the point of discharge. If this length be 12 miles there is a sum equivalent to 7% of the cost of the sewer rendered non-effective. There would be further charges for distribution and treatment.

In the case stated, then, it would probably be better to spend £75,000 on a water-tight sewer, if it were possible to get it, than to spend £60,000 on the one which leaks. (Of course this calculation is rough, and is made simply to show the importance of the matter.) Now cast iron and wood are the only linings used here, which could certainly be made water-tight. The cost of a cast-iron sewer in a shield tunnel is one-half more than that of a brick sewer in an ordinary timbered tunnel, and the wood lined sewer about the same as the brick sewer. The extra cost to exclude leakage would not be considerable for iron or wood lined tunnels.

In the Melbourne sewers a thick concrete lining was put in. In some European and American tunnels for traffic it is omitted, or only a thin lining is used to give a smooth surface over the flanges. The life of the cast iron appears to be considered as equal to that of the brickwork or concrete. In the Melbourne sewers this would not be so, and the cast-iron lining could not alone have been relied upon. The writer's opinion is that where the tunnel can be thoroughly grouted and examined at any time, the iron lining may be relied on, but it should be left exposed for examination as much as possible. In other cases, such as sewers, it should be lined, and the lining should be sufficiently strong to be complete in itself.

With cast-iron lining the concrete or other internal lining should not be put in under compressed air, at least until the iron lining has been made as water-tight as possible, and tested by reducing the air pressure. Otherwise leaks in the lining, which might be calked, will be covered up.

Erectors are used for putting the plates in place in large tunnels. In the St. Clair Tunnel the erector was attached to the shield and moved forward with it. It was worked by hand power. In the Hudson River Tunnel the erector was worked by hydraulic power, and mounted on a traveler moving on rails at about mid-height of the tunnel.

Two erectors were built in Melbourne. Each consisted of a truck, upon which was fixed the erector, consisting of an arm raised and extended by toothed gearing. The trucks were mounted on rails of wide gage, under which there was room for the earth trucks to pass. The erector was cumbrous, and on the one occasion that the writer saw it working, it appeared to be slow and clumsy. The second erector was not used to any extent. These designs were not suitable, and they appeared to have discouraged the use of erecting machinery. The plates were erected generally by the men without such assistance.

The writer sketched the following arrangement for an 11-ft. shield for erecting heavy plates, but it was never designed: A square shaft would project from the bulkhead, and upon this would slide a collar around which the crane or erector arm would be fixed on a bearing. The collar could be clamped to the shaft and the crane to the collar. The shaft would be fixed to the bulkhead at about 4 ft. 6 ins. from the top. The bottom plates can be thrown into place from the truck. The plates will come in about 2 ft. above invert, and the crane would be pivoted midway between this level and the top of the tunnel; and it would cause less inconvenience to the shovelers here. The crane would consist of two arms, one having an adjustable counterweight and the opposite one having a gearing for extending and withdrawing the arm, with a suitable arrangement at the end for picking up the plates. The plate could be lifted by the man depressing the counterweighted end of the erector, or, perhaps, by gearing. When the plate was brought opposite to its proper position, the arm would be fixed on the shaft, and the plate thrust into its place. When the ring was fixed the crane would be pushed back along the shaft to the bulkhead, where it would be less an obstruction while excavating. Of course, hydraulic power could be used. When the weight or plate exceeds 6 cwt. and the diameter of the lining exceeds 10 to 11 ft., the erector would be advisable.

WOOD LINING.

A patented system with wooden lining has been designed, and used with the shield at work at North Yarra main section, No. 6a, at North Melbourne.* The suitability and safety of the system have now been determined by its successful use over a length of more than half a mile of tunnel of 10 ft. in diameter.

The relative cost of 6-ft. 9-in. sewer, given later, indicates the objection to cast iron clearly. It is too costly. But in Melbourne work in bad ground it has these great advantages over such systems of lining as concrete and bluestone blocks—that the joints are not such as will be affected by water, the lining can be calked more readily, and, above all, whatever deformations may take place in the outer lining, the final internal concrete lining can be placed in position in a continuous mass, and without being exposed to subsequent disturbance. Half the cost of the completed work is about the actual price paid in Melbourne for the iron lining delivered at the shaft. The similar actual cost of the wood lining would be about one-fifth of the total completed cost of work. The cost of a finished concrete sewer with wood lining would be about 70% of the cost with cast-iron lining.

The wood lining is built in rings composed of sections. Each section consists of two-rib segments spaced the ring length apart, and covered on the outer side with boarding. Between the rib segments are placed thrust blocks, which will form continuous lines of struts to resist the pressure of the rams of the shield. Each succeeding ring is built so that the joints of its sections "break" with those of the preceding ring. Thus the lining has, at ring-length intervals, ribs really composed of two layers of wood secured together by bolts and breaking-joints, so that the whole will act as one piece. Of course, this result can only be secured by spiking the ribs together, or by drawing them together with strong bolts well screwed up. Probably the former would be the more efficient, and the latter the more convenient method. What has been written before about breaking joint in cast-iron lining applies here.

Some of the more evident peculiarities of this system may be criticised. There will be an unusually large number of joints, but the swelling of the wood will tend to prevent leakage through them. But if it were necessary to use boarding such that the joints cannot close up, the whole of the outer surface of the section may be covered with waterproofing material, as thin sheet metal, even overlapping across the joints with the sheeting of adjoining sections. The connection between the separate pieces of each section cannot be made sufficiently strong to render it nearly as rigid as a cast-iron plate. But the use of the thrust blocks will relieve the sections from the pressure of the rams, which is the principal cause requiring such rigidity. The more bulky timber will require a larger shield and excavation. This, however, will be compensated for by the lighter weight of sections in erection. It may be said that all the outer boarding is useless except for the purpose of transmitting the loading of the earth to the rib segments, and that in cast-iron lining the whole metal is available to resist the compressive loading of the ground. The primary purpose of the outer boarding is to transfer the earth loading to the ribs, which resist the compression. But if the boarding be closely fitted the swelling of the boards will cause them to act to a considerable extent as an arch, and, in any case, the subdivision of duties enables the designer to concentrate the material for resisting compression in stout and efficient sections. This cannot well be done with the cast-iron plates. In an alternative design of this system, iron is used for the ribs. For the laggings to resist cross-breaking timber is, price considered, the strongest material.

It is of importance that each leading ring of rib pieces be accurately retained in shape until the next ring has been securely attached to it.

When the shield is shoved forward the earth on top of the lining will usually close down and press upon it before, or heavier than it will at sides. To prevent deformation in the large excavated area behind the shield, it has been proposed to use a strong square "sett" of timber temporarily. This sett will be removed when the ground has closed around the lining.

*See Engineering News, Dec. 29, 1898, for a more extended description of this lining.—Ed.

SOME NOTES ON CENTRAL STATION HEATING.*

By William H. Bryan.†

Heating from central plants is not new, although the subject has only recently begun to attract extended notice. Nevertheless, the outlook is one of great promise. It is, of course, only feasible in cities of some magnitude, where large commercial buildings or residences are concentrated, and so located as to be readily reached from a central station. This is usually on the outskirts of the business section, where fuel and water are readily secured, and where ample room for growth is available. Many methods of central station heating have been employed, but they have now been reduced to practically two —steam and hot water. Experiments have been made with hot air, gas, and electricity, but without marked success.

Central station heating follows the same general laws which govern isolated installations. When the sale of steam is the main business of the plant, and there are no engines on which low back pressure must be carried, the steam pressure is high enough to force circulation to extreme distances, and in some cases even to run engines. Pressure reducers are supplied at the point of use to give the customer whatever indoor or secondary pressure he needs. Where part of the steam supply is from the exhaust of engines driving dynamos—as is often the case in modern plants—the pressure must be so low as not to interfere with the proper working of the engines. This necessitates larger mains, and is sometimes accompanied by difficulty in securing prompt and effective circulation, particularly where the mains are long and not well designed or located. The branch pipe leads to the house mains identically as if supplied by a local boiler. The indoor distribution may be either one or two-pipe, and needs no special design to fit it for central station work. It does not pay to bring back the returns to the station. The cost of the second pipe properly insulated, its rapid deterioration, and the frequent presence of oil or other foreign matter, has led to the abandonment of this practice. It is customary to install an "economizing" coil near the front of the house, over which external air is admitted, giving the necessary indirect heating and ventilation. The returns from the radiators pass through this coil, giving up practically what heat is left in them, and are then trapped to the sewer.

The main distribution system is of course always underground. The pipes must be large, and their temperature being high they must be thoroughly insulated with the best of material. It is also necessary to run a drain line of tile underneath each pipe line to prevent water from collecting and standing around the steam pipes. Suitable expansion joints, or "variators" are provided at frequent intervals; also man and hand holes for access to valves, joints, etc. Care must be taken in laying steam lines to prevent accumulations of water, all low points or pockets being drained and trapped to sewer. The steam system readily takes care of plants which have been installed to use hot water, as they have a surplus of radiating surface, and only a few very simple changes in the pipes are required.

Hot water systems are usually operated from central electric plants utilizing their exhaust. This has passed through closed exhaust heaters of large capacity, the outlet being to the atmosphere either direct or through a back-pressure valve. If the heaters are of ample capacity and properly arranged, there need be no back pressure. The water may be given any desired temperature up to 212° F. and is circulated by steam pumps. There is an outgoing and a return main, the distribution being what might be called multiple-series. At each building served a connection is taken from the supply main and serves the radiators, which are themselves in series or multiple-series. The returns are finally collected and go to the return main. There are a few instances of single pipe mains, the returns going back to the same main, being diverted to the house by a shunt.

There are two methods of regulation. In some cases the water is sent out at a constant temperature, and each individual user controls his radiators just as he would with his own plant, turning them on and off at will; or he may regulate them automatically by thermostats; or the entire plant may be handled by thermostats. In such an installation the speed of the pump varies, being controlled either automatically by a thermostat, or by an attendant who judges of the heat requirements by the temperature of the return water. In other installations the pump is operated at a fixed speed, the temperature of the water being changed with the weather. By adjusting the radiator valves of such installations the proper amount of water can be kept circulating through them, the customer thus being relieved of all care in the matter of regulation. The station attendant keeps close watch of an external thermometer, and raises or lowers the temperature of the outgoing water to correspond.

When the exhaust is insufficient, live steam may be admitted to the heaters, just as it would be turned into the mains with the steam system. In either case, separate boilers may be fired, discharging steam or hot water directly into the mains without the intervention of engines or heaters, a practice often followed.

In some few cases the attempt has been made to store surplus exhaust or its heat, at the time of maximum electric load, for use at times of maximum heat demand, but this involves considerable investment of capital and space, as well as a number of difficult mechanical problems. This is a feature of the work which will repay further study.

For some time efforts have been made to interest owners of electric plants in heating, with a view of utilizing their exhaust steam. Nearly all small plants—and many of medium size, as well as a few large ones—are non-condensing. On its face the proposition is attractive. Here is a waste, or by-product, which can apparently be sold at practically the full value of the original steam. The demand for heat comes at the time of year when there is the maximum demand for light, and when the greatest amount of coal is being burned anyway. Another attractive argument is that the thermal efficiency of the ordinary engine is only about 10%, rising in rare cases of exceptional importance to 15%. The remaining 85% to 90% can be saved and made revenue earning by turning the exhaust into heating mains. The companies already sustain business relations with their prospective heat customers, and many would be glad to contract with them for heating. In many cases additional contracts for light

*Abstract of a paper read at the seventh annual meeting of the American Society of Heating and Ventilating Engineers, New York city, Jan. 22, 23 and 24.

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and power can be secured which are not now available, as the owner must run his boiler for heating anyway.

It would appear that the scheme ought to present no particular complications in view of the universal use of exhaust steam for heating in isolated commercial buildings. In studying the subject a little closer, however, some difficulties arise. In the first place, the use of exhaust steam has usually necessitated a considerable back pressure on the engines, thus straining them beyond what they were built for, and reducing both their capacity and efficiency. Surprising as it may seem, it has been seriously claimed that not only is back pressure not objectionable, but that it is, on the whole, rather a good thing for an engine, as forcing it to buckle down to its work closely and restraining its desire to shirk. The testimony of builders and operators of engines is cited to show that no diminution either in capacity or efficiency is noticeable.

The fallacy of these statements has been amply demonstrated by Mr. Albert Spies and Professor Whitham, in communications to "Heating and Ventilation," for March and August, 1894, showing that the water rate per indicated horse-power hour increases fast with high back pressures. This would not be material if the demand for heat always equalled or exceeded that available from the exhaust. But this is frequently not the case, as is shown by Figs. 3 and 4. The situation is improved by separating the exhaust into two mains, and allowing only a portion of the engines to exhaust into the heating mains when the demand for heat is small. The exhaust from the remaining engines then goes direct to the atmosphere, without back pressure, or to the condenser.

It has also been stated that the effects of back pressure may be overcome by simply carrying a little higher boiler pressure. As even in simple engines the initial pressure is four or five times the mean effective, the boiler pressure would have to be raised by more than the amount of the back pressure. As most plants are already working close to their safe limit of boiler pressure this is rarely feasible.

How much heating patronage may an electric station properly take on? Let us assume a station having 1,000 HP. of rated boiler capacity, divided into, say 5-200 HP. units. One of these should be kept in reserve for cleaning and repairs. The remaining four boilers, rated at 800 HP., if of good modern design, will easily develop during the hours of maximum load, one-third additional, a total of 1,067 HP., equivalent, let us say, to the evaporation of 32,000 lbs. of water per hour. Allowing 5% for leakage and condensation losses through pipe system, engines, etc., and 15% for heating feed water, a maximum of 25,600 lbs. per hour of exhaust steam is available to be sent out into the heating mains. The loss due to condensation and leakage in the mains cannot be definitely determined, and is, in fact, variable, not only in different plants but in the same plant. It probably varies from 5% upward, but under no conditions should it exceed 25%. On the latter basis 19,200 lbs. of steam is available per hour for use in buildings. The condensation per square foot of average ordinary direct radiating surface, under the most severe conditions, runs from .25 to .3 lbs. per hour. On the basis of the latter figure, the steam available will supply continuously 64,000 sq. ft. of radiating surface.

In heating, however, there is a load factor, just as there is in light and power. Experience has shown that no matter how many lights, motors, or radiators may be connected to the station, they are never all on at once. Many stores, theatres, offices, rooms, and sometimes entire residences, are only in partial use, and are, perhaps, entirely out of use at certain times. I have been unable to secure any exact data as to what this load factor actually is for heating. It depends, of course, upon the system of service, and also on the rates, and whether flat or by meter. It would appear conservative, however, to put the average figure at 80%, on which basis it would be safe for the station under discussion to contract to serve 80,000 sq. ft. of ordinary direct radiating surface, or its equivalent. All of this is based on the assumption that the plant is primarily an electric station, and that it has not as yet been thought wise to install additional boilers or apparatus for the sole purpose of supplying heat. This may come later, but the attitude of the average plant today is that exhaust steam, and not electricity, shall be the by-product, the object being to increase the efficiency of the existing plant and force of operatives.

The above computations indicate that 80 sq. ft. of radiating surface may be connected for each rated boiler power of plant, assuming the usual boiler reserve of 20%, and ability to overwork of 33%. If we assume that the radiating surface throughout the city averages one square foot to 75 cu. ft. of space heated, each boiler horse-power will take care of 6,000 cu. ft.

The above figures are conservative. Under favorable conditions it would often be safe to take on 100 sq. ft. radiation for each boiler horse-power, or 7,500 cu. ft. of space. For severe conditions, however, the last-named figures are too high.

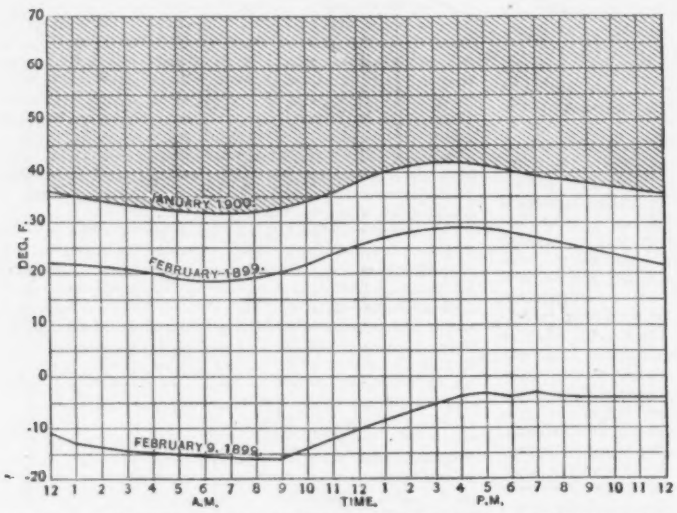


FIG. 1.—SHOWING MEAN HOURLY TEMPERATURE READINGS FOR THE MONTHS OF JANUARY, 1901, AND FEBRUARY, 1899, ALSO FOR THE COLDEST DAY OF THE YEAR 1899.

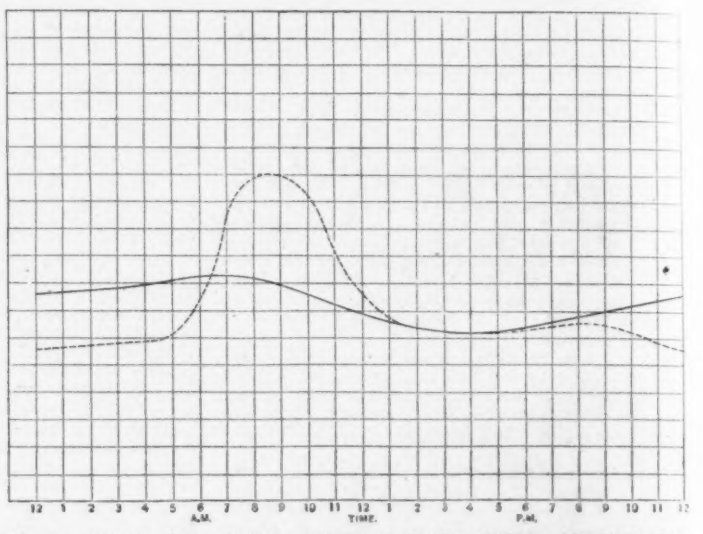


FIG. 2.—CURVE OF HOURLY HEAT DEMAND, WITH CORRECTIONS INDICATING PROBABLE DEMAND ON STATION.

Most electric stations keep records from which curves or charts are plotted, showing the output throughout the 24 hours. No such charts seem to have been kept by heating stations. The data ought to be easily secured by simply noting the temperature or speed of pump in the water system; and by hourly, or half-hourly, readings of counters on boiler feed pumps in live-steam stations. The demand for heat must, of course, closely follow the fluctuations of external temperature. I have secured from the St. Louis office of the United States Weather Bureau some interesting hourly temperature readings. Fig 1 gives the average hourly temperatures in St. Louis, Mo., for January, 1900, which is, perhaps, a fair average winter month. Fig. 1 also shows the curve for February, 1899, one of the coldest months. Also the readings for the coldest day of that month, which was, in fact, the coldest day of the year. The cross-sectioned area between the average line and 70° represents the heat which must be supplied to maintain the usual indoor temperature. This is a maximum between 6 a. m. and 8 a. m. and a minimum about 4 p. m. The range, however, is smaller than would ordinarily be assumed. In most heating systems, however, particularly those not regulated automatically or from the station, the demand for heat would not follow the curve exactly, but would lag behind it, an appreciable interval of time being necessary to make the external changes of temperature felt indoors. Furthermore, some normal deviations are to be expected. The most important of these is probably the turning off of heat in unoccupied buildings at night, and the shutting down of the heat in residences at bedtime. These would all be cut in again early next morning. This effect undoubtedly exists, but to what extent is difficult to determine.

In Fig. 2, the curve showing the heat required to maintain 70° has been inverted, and a correction intended to indicate what the actual demand for heat will probably be, has been made. In Fig. 3 the revised curve has been plotted upon an average load chart of an electric light station, and in Fig. 4, upon an average load chart of an electric railway station. In both cases the maximum output of steam for heating is made the same as the existing maximum for electric service. It is assumed that enough steam heating has been taken on to load the plant to this point, and that the boilers reach their maximum output twice daily, once for heating and once for light or power.

Fig. 3 shows that for five-sixths of the time the demand for heat exceeds the exhaust available, and that live steam must be used and additional coal burned for heating. From one-third to one-half the steam required during this period can be supplied by the exhaust, and the economy of the engine is of minor importance. Back pressure during this period is not objectionable, as the reduction of capacity, if noticeable, can be met by putting in more engines. For the remaining 15 to 20% of the time the exhaust exceeds the demand, and one-third to half of it goes to waste. The losses in engine capacity and efficiency from back pressure during this period are serious. It is clear that the crying need of this service now is a satisfactory apparatus by which the exhaust now wasted during the "peak" of the electric load, can be made available during the hours when there is a deficiency of exhaust.

Fig. 4 shows that the heat demand corresponds far better with the load of an electric railway, which indicates that exhaust heating is a better proposition for railways than for lighting plants.

Fig. 3 indicates the difficulty under which the average electric light station labors. No scheme of electrical storage having yet been found sufficiently cheap and efficient to come into general use, electric stations must generate current exactly as their customers use it. For a few hours each day, therefore, the plant works at its maximum, but for over 80% of the time a large portion of the equipment is idle. This adds greatly to the cost of generating electricity. Station managers are always on the lookout for means of making the work of the station more uniform, and of utilizing their station, equipment, and force, more hours each day. Central station heating offers advantages in this direction, as the entire boiler equipment and force can be utilized to advantage when the electric load is small by supplying directly from the boilers whatever deficiency there is in the exhaust for heating.

Is it possible to weigh the exaggerated and conflicting claims of the advocates of the steam and hot-water systems with a view of reaching an unbiased conclusion as to the particular features in which one or the other appears preferable? While it cannot be hoped that such a conclusion will meet the approval of either party, the interests of sound engineering would appear to make the attempt worth while. It is assumed, to begin with, that each installation is to be put in in good faith, and that the material and workmanship is to be first-class in both cases.

The following points of advantage appear to be with the steam system:

1. Simplicity. There being a single pipe line and no pumps being necessary.

2. The equipment or plant appears to be more durable. The life of underground pipe lines carrying steam has been shown to be much greater than those carrying hot water.

3. The investment in radiators for utilizing the heating service is less by the usual ratio between steam and hot water radiators.

4. The system will satisfactorily serve buildings which have been equipped for either steam or hot water heating. A hot water plant cannot handle a building equipped for steam heat, except at considerable expense for reconstruction.

5. Less pressure being carried there will be fewer leaks, and less liability to damage in case of accident.

6. Leaks may be repaired, valves packed, etc., without the necessity of shutting off the entire house.

7. The steam people have whatever advantage results from long experience in the heating business, and the construction and operation of many plants under wide ranges of condition.

The following advantages appear to be with the hot water method:

1. Cheapness of installation, although this is to some extent offset by the necessity for a return line. The low temperature makes it unnecessary to provide as many expansion joints, or to use as high a grade of insulating material, while the fact that the medium is water renders sub-drainage unnecessary.

2. Milder temperature, which is preferable in radiators, hot water now being used almost exclusively for residences. The low temperature also reduces the radiation losses, which are proportional to the differences of temperature.

3. There being no waste to sewer, either at low points or at discharge from residences, there is no loss of water or heat at these points.

4. Water appears to adapt itself readily to regulation, either automatically or by an attendant at the station.

5. Water appears to lend itself better to heat storage, which, as is shown in Fig. 3, would improve the economy of the station.

6. Operation without back pressure. While this is of less importance than would appear at first glance, it nevertheless should have the earnest attention of the steam advocates.

7. There are no offensive odors from the air valves or stuffing boxes of radiators.

8. It would appear to be easier to discover and locate serious losses of water or heat.

There appears to be no choice between the two systems in the matter of power required to circulate the heating medium. Fig. 3 shows that for five-sixths of the time the demand for heat exceeds the exhaust available, so that neither the back pressure on the engine nor the running of a special pump, would affect the total steam to be generated, as there is always a deficiency to be made up direct from the boilers. Both systems are wasteful in this respect during the peak hours. If, by the adoption of modern methods, steam can be distributed without back pressure, the system will then have an important advantage over water.

It would appear possible to meter both systems. The use of steam could be measured either directly by steam meters or by hot-water meters on the returns. In those water systems carrying constant temperature and changing the speed of pump to suit the demand, the water could also be metered. This could not be done, however, where the speed of pumping is constant and the temperature is varied.

It would be risky to hazard a recommendation as to choice of system, as every proposed location would vary in its conditions and requirements. Some general observations may be in order, however.

If the capital available is limited, and the most ground must be covered for the money, the water system would probably be selected. If the city to be served is hilly, or has many tall buildings to be served, the water system would appear to be undesirable on account of the high pressures which would have to be carried in order to reach the high buildings or districts, this pressure being likely to cause trouble in the low districts. If a preliminary canvass of the city shows that a majority of the buildings to be connected are already equipped for steam heat the steam system should be adopted, while a majority of hot-water plants would "indicate" that system.

As more steam is required to heat a building than to light it, a central plant can secure a sufficiently large heating patronage much closer the station than it can its light patronage. If the buildings to be heated are close at hand, so that the investment in expensive mains can be kept down, the advantages would be with the steam proposition. On the other hand, if considerable area is to be covered, considerations of first cost might limit the system to water. A point which appears to hamper the water system now is the uncertainty as to the life of underground pipe lines and their insulating conduits. Until the system has been in service for long periods of years, under all sorts of conditions of soil and climate, there will continue to be some hesitancy on the part of capital.

Not all electric stations can enter the heating field with profit. Many are located too far from the district to be heated. Cheap fuel and water, and ample room for present arrangement and for growth, usually determine the location of plant. In other cases the topography is such as to make it an attractive proposition for neither steam nor hot water. In some places the price of fuel is low, and in others the people have not been educated up to the point of appreciating artificial heat under modern methods, and could not be induced to pay a profitable price for it.

The rates charged for heating in different cities and under different conditions vary considerably. The conditions controlling the price are the cost of fuel, the distance the service is carried, range of external temperature, and number of months of service. In most cases the charge is for a season's service, and is based either upon the square foot of radiation, or 1,000 cu. ft. of space heated. The rates for hot water vary between 12½ cts. and 20 cts. per sq. ft. of radiation. For steam, the range is from 15 cts. to 30 cts., although a rate of 50 cts. is reported from Seattle. The charges run from $2.50 to $5. per 1,000 cu. ft. of space heated, which, of course, is independent of whether steam or water is used. A slightly higher charge is made for indirect radiation. When steam is sold by meter, the unit is the kal, which is the amount of heat required to evaporate one pound of water. This charge varies from 45 cts. to 80 cts. per 1,000 kals, depending upon the customer's requirements.

Experience in hot-water plants indicates an average consumption of coarse slack of about 55 lbs. per sq. ft. radiating surface per season. If we assume that one square foot of surface heats 50 cu. ft., then 1,100 lbs. of coal will heat 1,000 cu. ft. of space; or with slightly better coal it may be said that one pound per season will heat one cubic foot of space.

For some years it has been the almost invariable practice in isolated steam-heating plants to use one of the vacuum systems of handling air and returns. Heating in modern buildings is now done without back pressure on the engines. The use of such systems is entirely practicable in connection with central heating plants, and there have been some successful installations of this character. Their use, of course, adds somewhat to the complications, and materially to the first cost. The recently developed vacuum air valves—which prevent the return of air into radiators—seem well adapted to this purpose at small cost, in connection with steam systems. There seems to have been no such application of them however, and some doubt exists as to whether they can be kept tight. Their use would necessitate carrying a pressure of several pounds on the system for a few minutes every day to blow the air out of the radiators, but this could be done at a time when live steam was being used anyway. Traps of special construction would also be necessary to discharge the return into the sewer when there is no pressure in the system, and without admitting air.

Some revenue may be secured from the heating of hot water tanks, for baths, laundries, kitchens, etc. This service, however, is usually desired for the entire year, and it is only in rare instances that sufficient revenue can be secured to justify carrying heat on the mains during the summer months.

In Fig. 3 the curve represents the maximum output of both light and heat. In mild weather the heat curve would have the same general characteristics, but the output would be much less, and for considerable periods in the fall and spring, it might even drop to a point where the demand was equal to or less than the exhaust during periods outside of the peak. At such times no steam would be used direct from the boilers, and absence of back pressure on the engines would be of importance. This would also hold true for a considerable period after a new company enters the heating business, as it would require some time to secure enough contracts to utilize the full capacity of the boiler plant. During all these periods of service the exhaust might be ample.

The steam people claim that the demand for heat will soon reach a point where in cold weather it will utilize all the exhaust available, even at the peak of the electric load. If this is a fact, then Fig. 3 shows that the demand will be some 50% greater between 5 a. m. and 7 a. m. If the electric plant is worked to the limit of its capacity at the peak, as has been assumed, it would then be necessary to install additional boilers to take care of the early morning heating load. This changes the entire aspect of the problem and makes the station one which produces heat and sells its electricity as a by-product, instead of an electric station selling heat as a by-product. Such an installation may often be justified by circumstances, but it is foreign to the present discussion, which presupposes no additional investment at the station on account of entering the heating field.

It is true that steam at atmospheric pressure is not quite as effective as steam at 5 to 10 lbs. pressure. A good vacuum system of air removal would in most cases make the radiating service sufficiently more effective to overcome this difficulty. But as the maximum demand for heat comes at an hour when live steam must be employed anyway, there is no objection to carrying a somewhat higher pressure for short periods to overcome any deficiencies which might be found.

What is the best thing for a central station to do with its exhaust—put in condensing apparatus, and increase the capacity and efficiency of its engines 20 to 25%; or to run non-condensing, and sell the exhaust for heating?

Many points must be considered in answering this question, such as cost of fuel, cost of plant and water for condensing, capacity of engines, and work required of them, hours of loading, amount of the heating that can be secured, etc. Condensing increases the value of the steam only 20 to 25% as a maximum, while the sale of the exhaust for heating should bring 75 to 80% of its original value. It is evident, therefore, that when the exhaust can be sold for heating at fair rates and without too large an investment in plant, it is more profitable to do this than to condense. If the amount and duration of the load and the price of fuel are such as to justify condensing apparatus, it could be kept in operation throughout the non-heating season, and also during the heating season on those units from which the exhaust was not needed for heating, particularly during the peak of the load.

A concise statement of the advantages to the customer, the electric plant, and the general public, resulting from the installation of a central heating plant, may be worth making. The customer saves the expense of coal and ash handling, with their unavoidable accompaniments of dirt, dust, smoke, and soot. The saving of labor is a con-

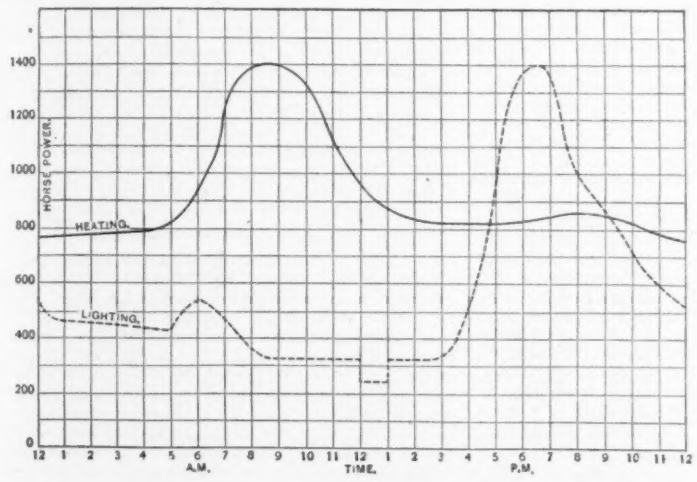


FIG. 3.—CURVE OF HOURLY HEAT DEMAND, COMPARED WITH THE OUTPUT OF AN AVERAGE ELECTRIC LIGHTING STATION, BOTH REDUCED TO BOILER HORSE-POWER.

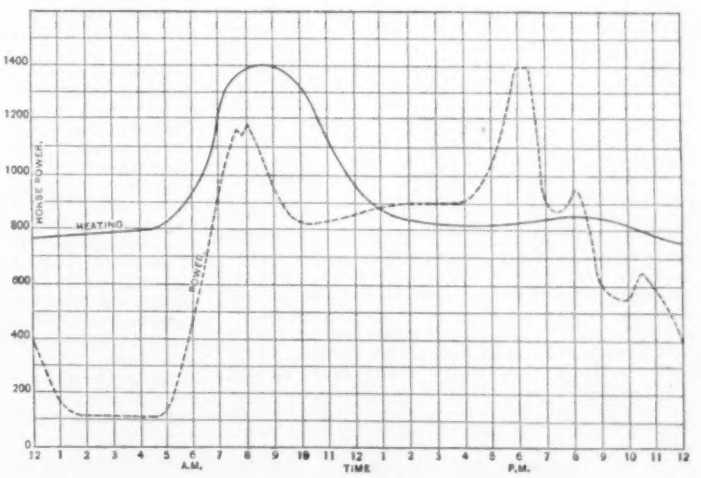


FIG. 4.—CURVE OF HOURLY HEAT DEMAND, COMPARED WITH THE OUTPUT OF AN AVERAGE ELECTRIC RAILWAY STATION, BOTH REDUCED TO BOILER HORSE-POWER.

siderable item, particularly in large plants. The heat supply is regular, continuous, and unlimited, and is available throughout the entire night and on Sundays and holidays. The building need never become cool. The heat is capable of regulation and adjustment with fluctuations in the external temperature. Valuable space in basements and cellars is saved, there being no longer any necessity for boilers or coal storage. It is possible to have a cool cellar, which is often an advantage where it is desired to keep vegetables or provisions. Insurance rates, too, are less where there is no fire in the building.

The service demanded of the ordinary heating boiler is so variable, and it has so little skilled attention, that its thermal efficiency is very low, rarely exceeding 50%, and averaging probably not over 35%. Furthermore, in order to keep fire over night, and to avoid making a smoke nuisance, it is almost imperative in many ordinary heating plants to burn the most expensive grade of the very best coal. In large St. Louis residences, for instance, anthracite lump of 13,000 British thermal units per pound, costing $7 to $8 per ton, is burned, with an average efficiency of 35%. Under the boilers of a central heating plant, slack coal or screenings, costing $1 per ton and having a calorific value of 10,000 British thermal units, would be burned, with an average efficiency of 60%. The fuel cost of the isolated plant under such conditions is ten or twelve times as great as that of the central station.

The heating business has attractions to central electric stations aside from the mere profit which the books may show. It adds to the permanency and security of the company's business, and, therefore, places the capital invested upon a more attractive footing. It often enables the company to secure contracts for electrical service which it would not otherwise get. The most difficult condition which the salesman of electric light and power meets, is where the owner must retain and operate a boiler plant to heat his building. He argues that the additional expense and inconvenience of operating engines and dynamos for light, elevator and power service, are not great. When a central station can supply heat as well as light and power, it is in a position to meet this argument and permit the customer to remove his boilers and utilize the space for other purposes, besides doing away with the many nuisances connected with the operation of his own plant, particularly through the summer.

There are advantages to the general public in central station heating in the concentration of the plant in an out-of-the-way location, in the reduction of the number of coal and ash teams on the streets, and the removal of the smoke nuisance, aside from the direct benefits obtained by those who make connection with the plant.

There are many incidental advantages connected with the use of central station heating beyond the mere saving of fuel. This service—while in many cases a necessity—is in some instances a luxury, and it should command a price accordingly. It is worth much more to a customer than the mere amount he saves, and he should be willing, therefore, to pay the central station a rate which will enable it to earn a fair return on the necessary investment.

While these notes indicate that there are many cases where central station heating would not be profitable to electric plants, it is nevertheless a fact that many cases exist where a small investment in this direction can be made to yield handsome returns. Just what can be done in any particular case, and whether steam or hot water is preferable, and what the details shall be, can only be determined by an intelligent and exhaustive study covering all local conditions. It goes without saying that such a study should be made by disinterested and competent persons who have no interest in the matter further than to discover and reveal to their employers all the facts bearing on the case.

THE INDIANA, ILLINOIS & IOWA R. R.*

By O. C. Whitsell.†

The Indiana, Illinois & Iowa Railroad runs from St. Joseph, Mich., to a junction with the Illinois Valley & Northern R. R. (now C., B. & Q. R. R.), near Ladd, Ill. From the I. V. & N. Junction to Fulton, Ill., it runs over a line leased from the C., B. & Q. R. R. Leaving St. Joseph, Mich., the line follows up the left bank of the St. Joseph River for 1½ miles, skirting the bluffs; thence taking advantage of the bluffs and small streams flowing into the river the ascent is made, with a grade of 30 ft. per mile, into the high ground, thence through a well-settled and highly productive farming and fruit raising country, the line bears nearly due south to the state line, and southwest to South Bend, Ind.

The country between St. Joseph and South Bend is rolling, but the character of the work is not heavy, averaging about 12,000 cu. yds. per mile. The grades are light. Leaving South Bend, the line passes over a few miles of almost level marshy ground, which marsh is the extreme head of the Kankakee River; thence southwest and keeping a few miles south of the Kankakee River, over a slightly rolling, agricultural country to North Judson. From North Judson to Streator the line runs almost due west. From Granville, the line bears northwest down the All Forks Creek, the valley of which stream it follows to the Illinois River. Almost directly opposite the mouth of All Forks Creek a stream called Nigger Creek comes in from the north. From the Illinois River the line runs almost due north up Nigger Creek to Seatonville, crossing the C., R. I. & P. R. R. with a 58-ft. through plate-girder bridge; which gives the C., R. I. & P. R. R. room for four tracks and leaves 22½ ft. clear headway above top of rail.

From Seatonville the line bears east of north, still following up the valley of Nigger Creek to Ladd, at which point it makes junction with the I. V. & N. R. R. The length of main track from St. Joseph to Ladd is 233.5 miles. In addition to the main track, the company has built several branches, from Kankakee to Bradley, two miles, to connect with factories; from Reddick to Cardiff, four miles, to connect with the Cardiff Co.'s coal mine; from the C., R. I. & P. R. R. crossing to Depue, 1¼ miles, for interchange track and from the same point to Marquette coal mine, track has been graded but is not yet laid.

From North Judson to De Motte the line runs through a flat country interspersed with sand hills; from De Motte to Momence it runs through what is known as the Kankakee marshes, crossing the Kankakee River at Shelby. These marshes are fast being drained and converted into farm lands. From Momence to Granville the line runs through the finest agricultural section of Illinois. At Kankakee and Carrow there are quarries of building stone; at Clarke City, Cardiff, Streator, Marquette, Seatonville and Ladd, some of the best producing coal mines in the state. Putnam county will also be producing coal at no distant day.

SURVEYS.

In making surveys for the extension west of Streator our preliminary surveys soon developed the fact that it was impossible to get down to the Vermillion River, from Streator, with a 0.5% grade, so the only thing left to do was to seek a narrow place and jump it, which was done. From Kangley to Granville there are no engineering difficulties and the question of location of line was decided by considerations of future traffic and a desire to accommodate to the fullest extent the country passed through. As All Forks Creek offered the easiest grade for getting down to the Illinois River, although somewhat crooked, it was adopted for the reason that it was the best that we could find, that was in the direction we desired to go.

In order to reach the summit north of the river at a point as far west as possible, it was necessary to make the foot of our grade near the river and to climb over the C., R. I. & P. R. R. track; to do this we had to build 4,129 ft. of trestle work from 20 to 40 ft. in height. At about the highest point on this trestle we had to put in a switch for a Y-track to connect with the C., R. I. & P. R. R. at Depue and also to enable us to reach the coal mine at Marquette. This added 1,057 ft. to the length of trestle.

After passing Seatonville the original location bore due north to Zearing on the I. V. & N. R. R., two miles west of Ladd. After construction was partly completed it developed that a connection with the Chicago & Northwestern Ry. east of Ladd was needed. Arrangements were accordingly made to use the C., W. & V. Coal Co.'s track from Seatonville to Ladd and there connect with the I. V. & N. track. The line to Zearing was accordingly abandoned and the line through Ladd adopted. From Ladd a line was constructed due east for three miles to a connection with the C. & N. W. Ry. Co.'s Spring Valley line.

CURVATURE.

Our standard maximum curve is 3° per 100 ft. for all main track outside of yard limits; but for special reasons it has been exceeded in two instances; we have one curve of 3° 20′ and one of 4°. Inside of yard limits where trains are compelled to run slow, we have curves of 6° to 10°. On the Bradley spur we have two 12° curves. These latter we find too sharp for mogul engines, which (although they go around the curves all right) on account of their longer wheelbase, are continually kicking the track out of line. I have not complete data of the curvature between St. Joseph and South Bend, but with the exception of the first two or three miles out of St. Joseph the curvature is light. Between South Bend and Streator there are 51 curves, having an aggregate curvature of 906.7° and an aggregate length of 11.55 miles, or 7.0% line. Of the new extension from Streator to Ladd, 78% is tangent, 15% is curves of over 2°, and 7% is curves of 2° and less.

GRADES.

In the original construction of the road there was used between Streator and Budd about two miles of 35-ft. grade and one mile of 33-ft. grade, rising to the east; and between Budd and Dwight some short pieces of 30 ft. grade falling to the east. With these exceptions all the grades betwen Streator and South Bend are less than our present maximum of 0.5 ft. per hundred or 26.4 ft. per mile.

With the assistance of a pusher up Budd hill, one of our compound engines, carrying a weight of 112,000 lbs. on their drivers, hauls 75 loaded cars from Streator to South Bend. It is the intention of the management to cut down all grades between Streator and Dwight to our maximum of 26.4 ft. per mile in the near future. On the new extension from Streator to Ladd, this maximum was adhered to in all cases except in the crossing of the Illinois River. Here, owing to the great elevation to be overcome (272 ft.) and the shortness of the distance we had to get down in, we were compelled to use a grade of 0.7%, or 37 ft. per mile. There is no compensation for curvature on this hill, as all engines loaded for 26.4 ft. grades would have to be pushed up this hill, and to compensate for curvature at the rate of 0.04 ft. per station per degree of curve, owing to the peculiar formation of the ground, would increase the cost of construction from $20,000 to $25,000, without the compensating advantage of doing away with the pusher.

IMPORTANT BRIDGES.

The most important bridges on the line are those over the Kankakee River at Kankakee, over the Vermillion River at Streator, and over the Illinois River. The Kankakee bridge consists of three wooden Howe truss deck spans of 138 ft. each, on piers and abutments of Kankakee stone. The Vermillion River bridge is a steel viaduct 548 ft. long and 71 ft. above the river bed. The viaduct is a deck girder supported by five steel towers of 30 ft. span and two single bents, all connected by six 58-ft. and one 50-ft. girder spans. The substructure consists of one abutment, three piers, and 14 pedestals, and is built of Portland cement concrete. The cost of both substructure and superstructure was $39,154. The Illinois River bridge consists of one 300-ft. draw span and two 120-ft. riveted steel spans. The substructure consists of first-class masonry piers, built partly of Cleveland sandstone and partly of Anamosa (Iowa) limestone. The piers rest on concrete foundations which extend below the bed of the river and are supported by piles driven to a firm foundation. The structure is first-class in every respect and cost when completed $101,433.

TRESTLE BRIDGES.

Our standard plans for trestles, as used on the extension west of Streator, we will probably change in the future by using 14-ft. spans and 28-ft. stringers, instead of 16-ft. spans and 32-ft. stringers as now. Between Streator and South Bend we have 155 pile bridges, the longest being 1,694 ft. and the shortest 8 ft., and having a total length of 11,515 ft., which is an average of 76 ft. per mile.

On the extension west of Streator the bridging was heavy, there being 44 bridges, ranging from 16 ft. to 5,186 ft. in length, and having an aggregate length of 10,367 ft., which is an average of 240 ft. per mile, and costing on an average $9.93 per lin. ft. The highest trestle is the one at the west end of the Vermillion River viaduct. It is 848 ft. long and from 20 to 50 ft. high, is of yellow pine frame bents supported by piles, and cost $11.71 per lin. ft. The low bridges, ranging from 5 ft. to 15 ft. in height, cost on an average $7.10 per lin. ft. For culverts we are using cast iron pipe of the weight and thickness known as standard gas pipe, the sizes principally used are 18, 24, 36 and 48 ins. inside diameter, in 12-ft. lengths.

SHOPS AND ROUNDHOUSES.

The company has at South Bend a roundhouse of six stalls, 70 ft. deep, with a 60-ft. iron deck turntable. At Kankakee is a machine shop equipped for doing all their own repair work on cars and engines, and a six-stall round house, with a 60-ft. iron deck turntable. There is also one of the finest icing plants in the state, consisting of one house 120 × 200 ft., and 30 ft. deep, holding 16,000 tons, and one house 30 × 240 ft., 28 ft. deep, holding 4,000 tons, equipped with movable platforms and modern machinery. The freight storage and transfer house is 70 × 450 ft. At Butts, two miles west of Kankakee, large storage yards are being built, and already have pens sufficient to water and feed a train load of cattle at once. At Streator is a seven-stall round house, with 55 ft. iron turntable, and it is proposed to build a round house at I. V. & N. Junction.

GRADING.

Our standard width of roadbed is 16 ft. in embankment, and 22 ft. in excavation, with side slopes of 1½ to 1. The first 28 miles west from Streator was moderately light work, averaging about 11,000 cu. yds. per mile. This was all constructed with wheel and slip scrapers. The next 12 miles averaged almost 64,000 cu. yds. per mile and was constructed almost entirely by steam shovel and dump cars.

TRACK CONSTRUCTION.

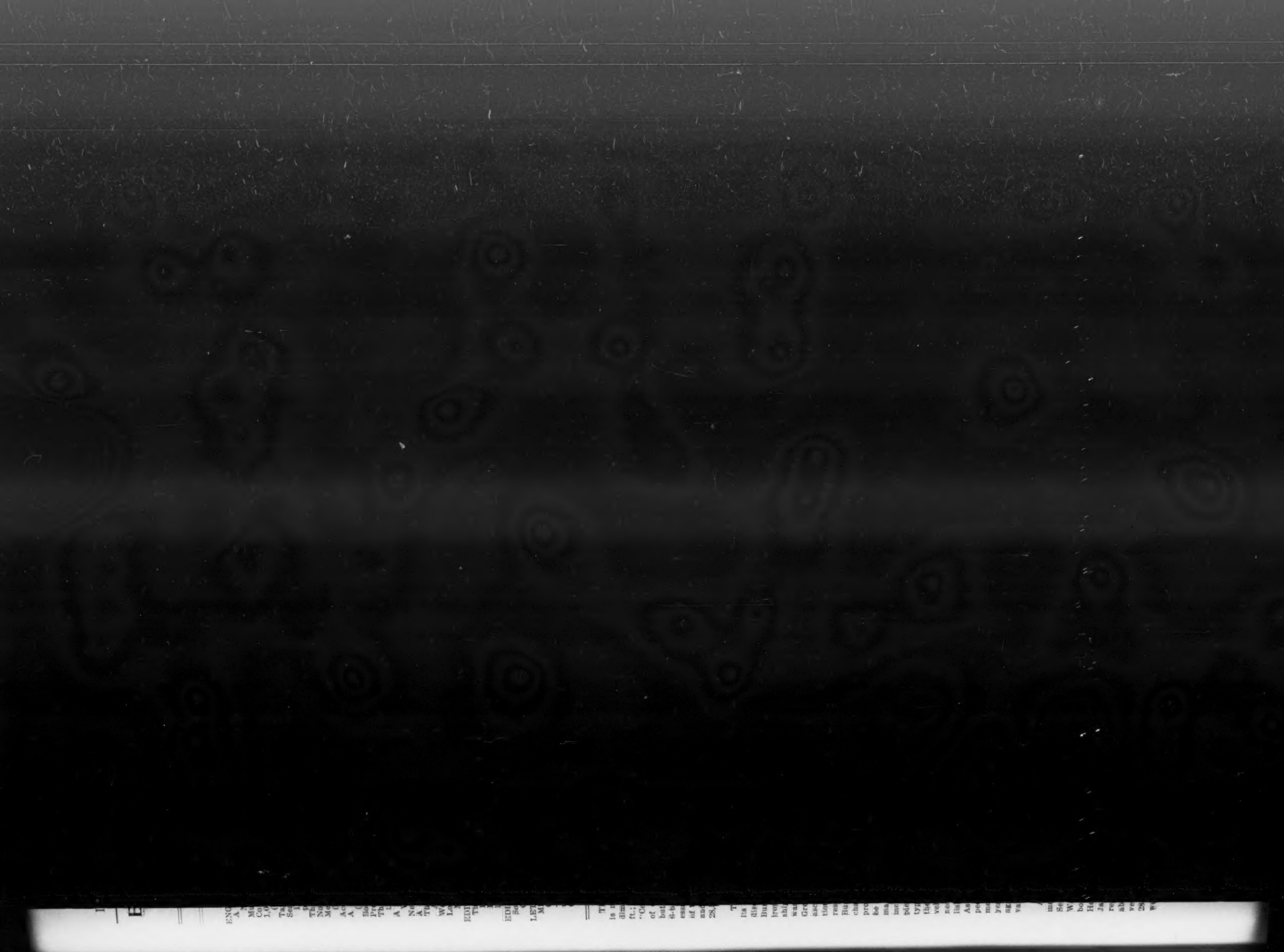
Our present standard is a 75-lb. steel rail of the Am. Soc. C. E. standard section, laid with broken joints, with 17 ties per 30 ft. rail (2,992 per mile). The joints are spliced with 24-in. angle bars and four ⅞-in. bolts with American nutlocks. All but about 12 miles was laid with an iron car and the ties handled by teams. The other 12 miles was laid with tracklaying machines.

BALLASTING.

About 10 ins. of gravel ballast was put under the ties. This was loaded by steam shovel and plowed off of cars by a center ballast plow, operated by a 1½-in. steel cable attached to the engine.

INTERLOCKING PLANTS.

Interlocking switches are placed at the following railway crossings: C. & A. (Dwight); Wabash (Reddick); C. & E. I., P. C. C. & St. L.; C. & E., N. Y., C. & St. L. Ry.; P., F. W. & C.; B. & O.; L. E. & W.; Wabash (North Liberty); L. S. & M. S. at South Bend; L. S. & M. S. at Rugby.

*Abstract of a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors.

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